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Control Over Multiple Forms of Instructional Assistance While Learning the Cascade Juggle

David Daniel Laughlin
dlaughl2@utk.edu

To the Graduate Council:

I am submitting herewith a dissertation written by David Daniel Laughlin entitled "Control Over Multiple Forms of Instructional Assistance While Learning the Cascade Juggle." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Kinesiology and Sport Studies.

Jeffrey T. Fairbrother, Major Professor

We have read this dissertation and recommend its acceptance:

Craig A. Wrisberg, Leslee A. Fisher, Schuyler Huck

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

Control Over Multiple Forms of Instructional Assistance While Learning a Cascade Juggle

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David Daniel Laughlin

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ABSTRACT

The purpose of this study was to examine the juggling performance and self-control behaviors of individuals in a self-controlled motor learning protocol. Of particular interest were behaviors related to how participants used four types of instructional assistance as they learned 3-ball cascade juggling: (a) Instructions; (b) video demonstration; (c) verbal feedback about their most critical error; and (d) verbal timing information about their previous attempt. Additionally the study addressed the potential interplay of performance, self-efficacy, self-control behaviors, and self-regulatory skills such as task clarification, goal generation, and use of learning strategies. Twenty undergraduate students completed practice sessions on four consecutive days. On the fifth day, participants returned for a 10-attempt retention test. They also completed a 10-attempt transfer test requiring them to juggle balls that differed in weight. In addition, participants completed up to four self-efficacy assessments and a post-training interview asking them to rate and describe their preferences for assistance, goal-related behaviors, and use of learning strategies. Juggling performance was assessed in terms of catches per attempt and participants were divided into groups based on performance in retention and transfer testing: Late Learners (n = 6) averaged fewer than 4 catches per attempt in retention and transfer; Emerging Learners (n = 8) averaged between 4 and 20 catches per attempt in retention or transfer; and Proficient Learners (n = 6) averaged greater than 20 catches per attempt in retention or transfer. Regardless of proficiency level, participants demonstrated a tendency to decrease requests for informational forms of assistance throughout acquisition. Requests for KR increased throughout acquisition for those who became increasingly proficient. Participants reported requesting KR after primarily good attempts and utilizing KR to monitor progress and increase confidence. Participants reported requesting KP after both good and bad attempts and utilizing

KP to identify mistakes and monitor their progress in correcting those mistakes. In general, the findings suggest that self-control behaviors may be more complex than previously demonstrated and that participants may use self-control in different ways depending on their preferences and learning needs.

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CHAPTER 1

Introduction

In recent years, researchers in the field of motor learning have been increasingly interested in the effects of allowing individuals to control some aspect of the training environment. Spurred by research in education, motor learning researchers began to investigate the effects of allowing individuals to be more active participants in their own training by giving learners control over selected aspects of practice (e.g., feedback presentation or video demonstration) that had previously been controlled by the experimenter (Zimmerman, 1989; Janelle, Kim, & Singer, 1995; Janelle, Barba, Frehlich, Tennant, & Cauraugh, 1997). Since the initial investigations of such manipulations by Janelle and colleagues (1995; 1997), numerous studies have produced a consistent pattern of results. Specifically, giving people control over some aspect of the training environment enhances learning (for a review, see Wulf, 2007). In the field of motor behavior, this form of self-regulation has generally become known as "self-control" (Bund & Wiemeyer, 2004) and the idea that providing this control enhances learning has become known as the "self-control effect" (Fairbrother, 2010).

Typical self-control designs include two experimental groups: Self-control (SC) and yoked (YK). Participants in the SC group are allowed to control some aspect of the training environment. For example, participants in self-control studies have frequently been given the option of receiving outcome-related feedback, or knowledge of results (KR), about their performance after each trial. Each participant in the YK group is matched to a particular participant in the SC group. YK participants receive the controlled aspect (e.g., KR) on the same schedule as their SC counterpart. Participants are typically matched by gender and hand preference prior to being matched by the self-control variable (e.g., feedback presentation).

Using this design, researchers attempt to ensure that the only difference between SC and YK groups is choice over some aspect of the training environment (Wulf, 2007).

In a relatively short period of time, evidence has accumulated to suggest that self-control effects are robust, with support from a variety of experimental tasks and modes of instructional support (Fairbrother, 2010; Chiviacowsky, Godinho, & Tani, 2005; Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008). The benefits of allowing learners to control some aspect of practice have been observed for the provision of outcome-related feedback (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Hansen, Pfeiffer, & Patterson, 2011; Patterson & Carter, 2010;), performance-related feedback (Aiken, 2011; Janelle et al., 1995; Janelle et al., 1997), and concurrent feedback (Huet, Jacobs, Carnachon, Goulon, & Montagne, 2009). In addition, benefits have also been seen for allowing self-control over the organization of practice schedule (Keetch & Lee, 2007; Titzer, Shea, & Romack, 1993; Wu & Magill, 2011), amount of practice (Post, Fairbrother, & Barros, 2011), access to video demonstration (Wulf, Raupach, & Pfeiffer, 2005), and use of physical assistance devices (Hartman, 2007; Wulf & Toole, 1999). Self-control effects have been observed in various populations besides apparently healthy college-aged adults, including sedentary individuals (Fairbrother, Laughlin, & Nguyen, 2011), Parkinson's patients (Chiviacowsky, Wulf, & Lewthwaite, 2011), and children (Sanli & Patterson, 2009).

In the earliest self-control studies, Janelle and colleagues (1995; 1997) proposed that self-control effects might be explained by deeper information processing, increased confidence, increased motivation, and the development of more effective learning strategies. More recently, Chiviacowsky and Wulf (2002) suggested that self-control might provide a learning benefit because it allows participants to tailor a practice situation to their specific learning needs and

preferences. Despite these speculative explanations, little published research has directly addressed the potential underlying mechanisms for self-control effects. Chiviacowsky and Wulf (2002) indirectly addressed the issue with respect to tailoring while acknowledging that the vagueness of most explanations for self-control effects (e.g., deeper information processing or increased motivation) makes direct testing extremely difficult. This admission, along with the lack of research directly addressing the mechanisms beneath self-control effects, suggests that there is a need to better understand self-control behaviors.

Recent calls urging researchers to consider the social cognitive aspects of motor behavior offer a potentially fruitful direction for more in-depth exploration of self-control behaviors while encouraging the use of more ecologically valid and complex tasks (Lewthwaite & Wulf, 2010a; Wulf & Shea, 2002). These calls also mirror the logic at the center of early self-control research, which relied heavily on ideas about self-regulation (Janelle et al., 1997; Zimmerman, 1989). Put simply, self-regulation refers to a level of engagement during learning such that self-regulated learners are more engaged both cognitively and behaviorally (Zimmerman, 1989). Ideas about self-regulation, which emerged from examining behaviors of students in relatively unconstrained learning environments, inspired researchers in motor behavior to depart from the traditional model of experimenter-controlled training environments. Participants were given control over an aspect of the practice setting and this resulted in superior performance on tests of learning compared to participants not afforded the same level of choice. To extend current understanding of the role of the active learner, however, it may be best to provide participants with even greater amounts of control over more than one aspect of instructional assistance as they learn more realistic tasks. Janelle et al. (1997) acknowledged the possibility that self-regulatory skills, or the degree to which a learner *effectively* self-regulates with respect to a learning goal, may have

contributed to observed learning advantages and encouraged future researchers to continue to explore ”the interplay of other self-regulatory skills (such as task clarification, goal generation, and strategic planning) with feedback effectiveness‘ (p.277). Allowing participants the opportunity to control a learning environment while tracking behaviors related to self-regulation may provide valuable insights into the mechanisms underlying the self-control benefit.

In framing their own studies, Janelle and colleagues (1995; 1997) relied heavily on Zimmerman’s (1989) ideas about self-regulation, and, specifically, the argument that individuals can be ”described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning‘ (p.329). Zimmerman’s definition highlighted the importance of three elements: (a) the use of learning strategies; (b) perceptions of self-efficacy; and (c) commitment to goals. Learning strategies include actions directed at acquiring information or skill (e.g., seeking information or rehearsing). Self-efficacy refers to beliefs about one’s capabilities to successfully perform a given task (Bandura, 1997). For the purposes of motor learning, goals are targets for behavior related to either the process or outcome of a movement skill and will vary considerably from individual to individual and situation to situation (Schmidt & Wrisberg, 2008).

Only one motor learning study has assessed self-efficacy within a self-control protocol. Bund and Wiemeyer (2004) found that participants given self-control reported higher levels of self-efficacy while learning a table tennis forehand than their yoked counterparts. In contrast, traditional motor learning protocols have focused almost exclusively on learning strategies and goals, but not in ways that might be expected to support self-regulation. That is, motor learning research has typically been interested in testing the relative effectiveness of learning strategies that have been identified *a priori* by the investigator as potentially important and goals regarding

task performance have been largely pre-determined (and narrowly defined) to establish appropriate levels of experimental control. These manipulations are inconsistent with recent suggestions that motor learning may better be understood through careful consideration of the social cognitive elements relating to skill acquisition (Lewthwaite & Wulf, 2010). Such calls, coupled with a lack of understanding about the mechanisms underlying the self-control benefit, highlight the need to examine self-control behaviors in new ways.

Approaches to better understanding self-control behaviors should not be limited to traditional protocols that have largely conceptualized self-control as a dichotomous "yes-or-no" choice over one aspect of practice (e.g., feedback, video demonstration, or physical guidance). Although this approach to investigating self-control effects has been invaluable in showing the benefits of giving learners control, additional insight can be gained by the use of alternative techniques (Martens, 1987). Self-regulation is a matter of degree and individuals can be described as self-regulated to the degree that they are active participants in their own learning (Zimmerman, 1989). One alternative approach would be to provide learners with control over multiple aspects of an instructional protocol, thereby allowing them to vary the degree to which they implement individual learning strategies. Such a design may be more sensitive to potentially subtle decisions that individuals make about using information.

Allowing SC participants to control multiple aspects might also provide insight into some interesting observations from researchers involved in previous self-control studies. For example, several studies have shown that SC participants tend to decrease requests for support as they progress through acquisition (e.g., Chiviacowsky & Wulf, 2002; Janelle et al., 1997). It is possible that this behavior is due to unique properties of the available support that influence learners' perceptions of its perceived usefulness for learning a specific and relatively simple task.

Providing SC participants with a range of alternative instructional support (e.g., instructions, demonstrations, KP, and KR) would presumably provide a richer picture of how learners prefer to use information as they learn. The use of a relatively complex task would also increase ecological validity and the likelihood that learners would explore different strategies for using different types of instructional assistance as they gain proficiency.

Another alternative approach to examining self-control effects is to consider both quantitative and qualitative aspects of performance, behaviors, and participant attributes. Perhaps the first step toward understanding self-control behaviors from a different perspective would be to combine these alternative approaches in a study that provides learners with multiple types of instructional support as they learn a relatively complex task. Self-regulation, which is at the foundation of self-control research, is fundamentally based on the degree to which individuals are able to control their own learning environment. By asking participants to control multiple types of instructional assistance, self-control behaviors (e.g., the frequency of requests for one type of support compared to the others) will become a more sensitive index of the degree of learner engagement. These observations in conjunction with performance data, other practice-related behaviors, interview responses, and participant attributes may offer new insights into both the cognitive and behavioral dimensions associated with self-control in motor learning.

Potentially useful tasks for such a study should be both realistically attainable for most participants but complex enough to require more than cursory amounts of practice. Three-ball cascade juggling is a task that seems to fit these criteria (Bebko, Demark, Osborn, Majumder, Ricciuti, & Rhee, 2003) while also being inherently motivating enough to attract widespread interest from people wanting to learn. Although cascade juggling can be learned in the absence of augmented feedback, mastering correct technique should be facilitated by such information.

In addition, juggling affords the use of various types of instructional assistance to potentially enhance skill acquisition. In the early stages of learning, individuals are mostly attempting to discover what actions are necessary for goal achievement (Adams, 1971; Schmidt & Lee, 2011). Initially, instructions and demonstrations may be most valuable to learners as they attempt to develop a sense of the proper technique. Once they understand what to do, however, they may prefer information that better helps them refine their technique (Schmidt & Wrisberg, 2008). In the middle stages of learning, individuals are often attempting to make subtle changes (Schmidt & Lee, 2011). At this point, feedback about their technique might be most useful. Instructions and demonstrations, while extremely useful for gaining the sense of the movement, cannot provide specific information about changes necessary in an individual's technique. As participants progress in learning, it would seem they move from information explaining juggling technique to information detailing the quality of their specific juggling technique. Eventually, information about the length of time they continuously juggled might become most valuable. This information could serve to help individuals assess how subtle technique changes influence performance or simply allow participants to monitor their progress. Because attaining proficiency often requires practice over several days (Bebko et al., 2003; Haibach, Daniels, & Newell, 2004), the use of juggling as a task may allow individuals to progress through stages in the learning process and offer a more extensive examination of practice behaviors than has been accomplished in previous self-control research.

Statement of the Problem

Current understanding of self-control behaviors and the potential mechanisms underlying self-control effects is limited. This is largely due to experimental approaches that have forced a potentially false dichotomy onto participant choices regarding instructional assistance, failed to

fully incorporate appropriate qualitative methods, and generally lacked a high degree of ecological validity. To resolve some of these shortcomings and extend knowledge regarding the performance, behavior, and attributes of participants in self-control protocols, it seems valuable to observe learners provided with multiple types of instructional support as they learn a relatively complex task over several days. Such an approach might provide a richer picture of how the provision of self-control impacts motor performance and learning and offer important insights into the potential mechanisms underlying self-control effects.

Purpose of the Study

The purpose of this study was to examine the juggling performance and self-control behaviors of individuals in a self-controlled motor learning protocol. Of particular interest were behaviors related to how participants used the four types of available instructional assistance as they learned 3-ball cascade juggling. Additionally, the study addressed the potential interplay of performance, self-efficacy, self-control behaviors, and self-regulatory skills such as task clarification, goal generation, and use of learning strategies.

Assumptions

1. Participants performed the experimental tasks to the best of their ability throughout the study.
2. Participants were naïve to the purposes of the study and had limited experience with the experimental task.

Delimitations

1. The study sample consisted of undergraduate and graduate students from a southeastern university in the United States.
2. Participation in the study was voluntary.
3. The study was conducted in a laboratory setting.

Definition of Terms

Acquisition. The initial phase of a motor learning study during which the participant is introduced to the task and completes practice trials.

Augmented feedback. Information about a movement that would not be known to a learner without the aid of some individual or device (Fairbrother, 2010).

Barrier knockdown task. An experimental task that requires participants to knock down a set of standing blocks in a particular order when prompted.

Blocked practice. Schedules in which all of the trials of one task are practiced before trials of any of the other tasks are introduced (e.g., AAA, BBB, CCC).

Cascade juggling. Basic form of 3-ball juggling where each ball travels in a figure eight pattern from hand-to-hand (Finnigan, 1992).

Concurrent feedback. Feedback that is provided simultaneously to performance (e.g., a display on a screen indicating if participants are pacing correctly while on a treadmill).

Feedback. Performance-related information that a learner receives during and/or after skill execution (Magill, 2001).

Instructional assistance (IA). Any form of augmented feedback available to individuals that may enhance learning.

Knowledge of performance (KP). Augmented feedback about the nature of a movement (Fairbrother, 2010).

Knowledge of results (KR). Augmented feedback about the outcome of a movement (Fairbrother, 2010).

Random practice. A practice schedule in which the tasks are presented randomly and no task is repeated more than once in immediate succession (e.g., ABCBABACB...).

Retention. An assessment of performance following a period without practice to determine the degree of learning that took place during acquisition.

Self-control. Allowing a learner to control some aspect(s) of a training environment.

Self-efficacy. A situation-specific form of self-confidence that refers to beliefs about the capabilities to plan and execute the behaviors needed for success in a given situation (Bandura, 1997).

Self-regulation. The degree to which individuals are behaviorally and cognitively active participants in their own learning (Zimmerman, 1989).

Stabilometer. A device requiring participants to remain in balance on a platform (i.e., keep the platform as close to parallel as possible) that is supported on an axis.

Transfer. An assessment of learning requiring participants to perform a slight variation of the skill practiced during acquisition.

Yoked. A control group that is matched to a self-control group with respect to the schedule of the self-controlled aspect(s) of training.

CHAPTER 2

Review of Literature

The purpose of this chapter is to provide greater detail about topics most relevant to this study. Self-control researched emerged primarily from two lines of study: Feedback research in motor learning and theories of self-regulation in educational psychology. Given the background of self-control research, this chapter will consist of subsections addressing these areas. Although these sections may include concepts that are only indirectly related to the focus of the current study, they are nevertheless important to broader issues and allow a greater understanding of the study rationale, design, and method. The chapter will begin with a general overview of feedback, self-regulation, and self-efficacy. Next, more specific detail will be provided about self-control and skill acquisition. Specifically, this section will include sections on how self-control has been explored with respect to feedback presentation, practice organization, amount of practice, model presentation, and physical assistance. It will also detail how participants have behaved in self-control settings with respect to their preferences for assistance. The chapter will also include a section discussing self-control and realistic training environments. The chapter will conclude with a section addressing the relationship between self-control research and ideas about learner self-regulation.

General Background

Feedback. Feedback is performance-related information that a learner receives during and/or after skill execution (Magill, 2001). Although the importance of feedback has been debated at times, it has long been recognized as fundamental to motor skill acquisition because it provides information that helps individuals make adjustments to improve performance (Magill, 1994; Fairbrother, 2010). Individuals have access to a wide variety of sensory information as a

result of movement (e.g., visual or tactile information), but researchers in motor behavior have been most interested in information that is only available from an outside source. This information, called augmented feedback, may serve several functions and play various roles in skill acquisition. The two main types of augmented feedback are knowledge of results (KR) and knowledge of performance (KP). KR refers to information about the outcome of a movement (e.g., a sprinter's time in a 100m race) while KP refers to information about the quality of the movement itself (e.g., a sprinter's angle upon leaving the starting block). Although KP is more frequently used in applied settings, KR has been the focus the majority of research examining the role of augmented feedback in skill acquisition (Magill, 2001).

Feedback is thought to play several functions with respect to skill acquisition. It can relay information (Adams, 1971), enhance motivation (Schmidt & Lee, 2011), provide reinforcement (Schmidt, 1975), and sometimes cause dependency (Schmidt & Wrisberg, 2008). At the most basic level of consideration, feedback can be viewed as a means to relay important information to performers about the success and relative effectiveness of their movements with respect to explicit performance goals. Accordingly, early researchers promoted the idea that higher frequencies of feedback were associated with superior learning (for a review see Adams, 1971). Later, researchers recognized that much of the evidence promoting this idea failed to include retention and/or transfer tests (Salmoni, Schmidt, & Walter, 1984), which are now considered necessary parts of any experimental design purporting to examine learning, per se. Studies directly manipulating the frequency of feedback administration have revealed that lower frequencies can enhance performance during delayed tests of learning (e.g., Winstein & Schmidt, 1990). These findings have been interpreted as indicating that learners can become dependent on feedback during practice if it is presented too often. This dependence subsequently hinders

performance once access to feedback is removed during testing (Schmidt & Bjork, 1992). Interestingly, studies employing high frequencies of feedback for individuals learning complex skills have not produced the same negative effects as studies examining simple skills (Wulf & Shea, 2002). Thus, it appears that the need for feedback information (at least from a frequency standpoint) is mediated by the challenge the learner faces.

Along with providing information, feedback is also thought to enhance learner motivation. For example, feedback might make tasks more interesting, increase alertness, and inspire more ambitious goal setting (Schmidt & Lee, 2011). Ultimately, these effects may then promote greater amounts of practice and more effective learning. Recent research has also shown a direct connection between feedback and motivation. Chiviacowsky & Wulf (2007) provided participants with feedback that was focused on either so-called "good" or so-called "bad" attempts as they learned to toss a beanbag at a target. One group received feedback about their three most accurate (i.e., "best") trials in each block while the other received feedback about their three least accurate (i.e., "worst") trials. Although both groups performed similarly during acquisition, the "good" feedback group performed more accurately during retention. A follow-up study measured intrinsic motivation levels of participants learning a golf putting skill in a similar protocol. The "good" feedback group reported higher levels of intrinsic motivation than the "bad" feedback group (Badami, VaezMousavi, Wulf, & Namazizadeh, 2011). Another study provided participants with false feedback that provided a comparison of their own performance to the purported average performance for other participants. The "above average" group performed more accurately than the "below average" group during transfer testing (Lewthwaite & Wulf, 2010b). Together, these studies suggest that the motivational properties of feedback are directly tied to participants' perceptions about the quality of their performances.

The relationship between augmented feedback and skill acquisition depends primarily on a performer's access to inherent sources of information and on the performer's ability to use that information effectively (Magill, 1994). If an individual has access to such information and is capable of using it effectively, it may be best to withhold augmented information (Schmidt & Wrisberg, 2008). If an individual has limited or no access to intrinsic information – as is often the case in experimental settings – feedback is necessary for any learning to occur. In most practical settings, however, feedback will serve to help individuals achieve a greater level of ultimate performance or achieve performance more efficiently. Because it can serve to hurt performance, however, care must be taken to give appropriate feedback and push performers to continue to make connections between their movements and their own sources of sensory information.

Self-regulation. Self-regulation refers to a self-directed process of learning that involves self-generated thoughts, feelings, and behaviors oriented toward specific goals. It is not a single trait and it does not happen without intention. It is a purposive and selective use of processes to adapt to a learning situation (Zimmerman, 2002). Effective self-regulation demands that learners possess a belief that they have control over the environment, their thoughts, their motivation, and their behaviors (Schunk & Zimmerman, 2009). Several components are involved in a learner's ability to be self-regulated: Setting specific goals, adopting strategies to achieve goals, monitoring performance for progress, restructuring the environment to meet goals, managing time, evaluating methods, attributing results to actual causes, and adapting methods as needed (Zimmerman, 2002). Consistent within the wide variety of definitions is that self-regulation refers to a systematic process of setting goals and behaving in ways consistent with achieving those goals. This includes monitoring and controlling both thoughts and actions (Wu, 2007).

In its most basic sense self-regulation is the ability to direct the learning process (Winne, 1995). As such, it is not an accidental process. According to Zimmerman (1989), "students can be described as self-regulated to the degree that they are metacognitively, motivationally, and behaviorally active participants in their own learning process" (p.329). Specifically, students must employ learning strategies to achieve specific goals to qualify as self-regulated. Self-efficacy regulates the entire process and directly affects how individuals select strategies (Zimmerman & Martinez-Pons, 1990). Zimmerman's definition includes three key elements: (a) use of the learning strategies; (b) perceptions of self-efficacy; and (c) commitment to goals. Strategies include actions directed at acquiring information or skill. They include organizing and transforming information, seeking information, and rehearsing. Self-efficacy perceptions include beliefs about capabilities to implement the actions necessary to achieve a desired performance (Bandura, 1997). Goals will vary by individual and time, but exist as a reference against which progress can be periodically measured. Among the three elements, self-efficacy emerges as the key personal influence. Perceptions of self-efficacy continually serve to regulate strategy use and goal commitment. Learners are said to be self-regulated to the degree to which they can use self-efficacy perceptions to strategically regulate their behaviors and their environment. Self-regulation, however, is not viewed as an absolute state of functioning. Consistent with Bandura (1977; 1978), Zimmerman did not describe self-regulation as a strictly internal process. Instead, he assumed self-regulation to be influenced by both the environment and behavioral events in a reciprocal manner. The three influential processes (i.e., person, environment, and behavior) are dynamic and serve to impact self-regulation. Therefore, self-regulation will vary in degree depending on personal, environmental, and behavioral factors.

More generally, the self-regulatory process can be conceptualized in terms of its phases: forethought, performance, and self-reflection (Cleary & Zimmerman, 2001). The forethought phase involves goal setting and strategy choice, and is primarily influenced by self-motivation beliefs (e.g., self-efficacy, outcome orientations) (Zimmerman, 2002; Schunk & Zimmerman, 2009). The performance phase involves strategy use and self-monitoring (Cleary & Zimmerman, 2001). The self-reflection phase involves self-evaluations, causal attributions, and self-satisfaction (Cleary & Zimmerman, 2001). It is in this final phase that performance is compared to some standard (Zimmerman, 2002). In simple terms, self-regulation involves systematic planning, performing, and evaluation that will vary depending on personal, environmental, and behavioral factors.

Self-efficacy. Self-efficacy is a situation-specific form of self-confidence that refers to beliefs about the capabilities to plan and execute the behaviors needed for success in a given situation (Bandura, 1997; Feltz, Short, & Sullivan, 2008). Self-efficacy involves perceptions (Duda & Treasure, 2010) that are specific to a domain and represent not what skills people feel they possess but rather what they feel that they can accomplish with those skills (Bandura, 1997). Self-efficacy beliefs vary along three dimensions: level, strength, and generality. Level refers to an individual's expected performance. Strength refers to the certainty of beliefs. Generality refers to the belief that capabilities can transfer to different levels of difficulty and different tasks (Feltz, Short, & Sullivan, 2008). Bandura argues that self-efficacy influences thoughts, emotions, and behaviors (Bandura, 1997) and that it regulates motivation and performance (Bandura, 1997). In addition, individuals higher in self-efficacy beliefs are more likely to give better effort, pursue challenging tasks, experience positive emotions, and experience less anxiety (Duda & Treasure, 2010). According to Bandura (1997), self-efficacy beliefs develop from four sources:

previous experience, vicarious experience, verbal persuasion and social influences, and physiological and affective states (Bandura, 1997). Self-efficacy beliefs are thought to influence many characteristics of participation. Self-efficacy beliefs can impact the choice of activities, goals people set, levels of effort and persistence, thought patterns, emotional reactions, and performance (Feltz, Short, & Sullivan, 2008). The substantial body of research in self-efficacy suggests that self-efficacy beliefs contribute significantly to levels of motivation and performance (Bandura, 1997).

Because self-efficacy is situation specific, however, standard instruments may not be ideal for its measurement (Bandura, 1997; Feltz, Short, & Sullivan, 2008). Instead, self-efficacy is best addressed with specifically designed instruments that follow suggested guidelines (Bandura, 1997; Feltz, Short, & Sullivan, 2008). Typically, respondents are asked rate items portraying different levels of task demands on a scale of 0 to 100 with 10-point intervals (where 0 = cannot do and 100 = certain can do). Respondents are directed to make present focused judgments by "can do" statements instead of "will do" statements. The optimal level of specificity in items depends on what predictions are being made and what knowledge exists about situational demands. If the goal is to predict or explain a particular level of performance in a specific situation, high levels of specificity are ideal. In practice, an intermediate level of specificity that measures self-efficacy for a class of performances within the same activity domain under a class of similar conditions offers good predictive value (Bandura, 1997; Feltz, Short, & Sullivan, 2008).

Self-Control and Skill Acquisition

In many instructional settings, learners are told exactly what to do and when to do it. In addition, they are provided with feedback when the coach, instructor, or therapist feels it is

necessary. Feedback is usually given after unsuccessful attempts to offer corrective information. For years, research in motor learning applied the same principles with experimenter-controlled training environments. More recently, researchers in the field have begun to allow participants to control some aspect of the training environment. In a series of motor learning experiments in the late 1990s, Janelle and colleagues cited self-regulation research as a justification for giving learners some control over the practice environment while learning new motor skills (Janelle et al., 1995; Janelle et al., 1997). Noting that research in motor behavior had, to that point, neglected the active role of the learner, Janelle and colleagues allowed participants to control the presentation of certain forms of feedback while learning a non-dominant hand throw. The results indicated that learners who were given control over the presentation of feedback learned the skill more effectively than those who were not allowed to control the presentation of feedback (Janelle et al., 1997). A yoking procedure was used to match participants who were given control of feedback presentation to those who were not to ensure that the frequency and schedule of feedback remained consistent throughout the study. The only difference between the groups was the ability to control the feedback schedule (Janelle et al., 1997). Findings from Janelle and colleagues inspired additional researchers to investigate the effects of giving learners control over other aspects of the learning environment. Subsequent studies challenged traditional ideas about instruction by consistently demonstrating that participants who were given control over some aspect of training performed better than participants not afforded such control (Fairbrother, 2010). Within motor learning, the idea that providing self-control produces learning effects was often referred to as the “self-control effect” or “self-control benefit.” In a relatively short period of time, evidence accumulated to suggest that these self-control effects were robust and extended

across many facets of learning (Fairbrother, 2010; Chiviacowsky, Godinho, & Tani, 2005; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008).

Feedback presentation. Feedback is performance-related information that a learner receives during and/or after skill execution (Magill, 2001). While the importance of feedback has been debated at times, it has long been recognized as fundamental to motor skill acquisition (Magill, 1994; Wulf & Shea, 2002). Motor learning research has primarily focused on the role of augmented feedback, which refers to performance related information provided to a performer by an outside source (Fairbrother, 2010). Early research theories on feedback argued that augmented feedback was absolutely necessary for any learning to occur (Magill, 1994). Researchers now understand the relationship between augmented feedback and learning to be more complex (Magill, 2001). Given its importance to motor learning, it is not surprising that early investigations of learner-controlled training environments targeted feedback as an independent variable (Janelle et al., 1995; Janelle et al., 1997). While researchers have expanded self-control studies to include other aspects of training (e.g., practice schedule, physical assistance, video demonstrations), feedback continues to be of interest in self-control studies (Hansen, Pfeiffer, & Patterson, 2011; Patterson & Carter, 2010). The body of self-control research addressing feedback has offered additional support for many of the existing ideas about feedback while also revealing new information about the role of feedback in motor skill acquisition.

The majority of studies addressing self-control over the presentation of feedback have taken the same approach seen in most traditional feedback studies: Participants are asked to learn novel tasks in which the available intrinsic feedback is of limited use. Typically, a group of self-control (SC) learners are given control over the presentation of knowledge of results (KR).

Another group - the yoked (YK) condition - consists of participants who are provided with feedback on the same schedule as a counterpart in the SC condition. This design ensures that the only difference between the two experimental groups is the ability to control when feedback is delivered (Wulf, 2007). Although this design does equate the amount and schedule of feedback—two variables known to influence performance and learning—it introduces a few factors that may prove to be important. For example, SC participants have foreknowledge of upcoming feedback (since they control it), but YK participants do not. In addition, the extent to which a particular feedback schedule provided to a YK participant matches his or her preferences is presumably due to chance (since yoking procedures do not take such preferences into account).

Several methods have been used to limit intrinsic feedback, including the use of tasks that provide little if any useful information outside of that provided by the researcher. For example, sequential timing tasks require participants to learn key pressing sequence in a particular order and/or timing pattern (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005; Hansen, Pfeiffer, & Patterson, 2011; Patterson & Carter, 2010). The results of such studies have been remarkably consistent: Both YK and SC conditions tend to show improvement during training, but SC groups perform more accurately than YK groups when tested without KR after a delay (e.g., 24-hours) (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Hansen, Pfeiffer, & Patterson, 2011; Patterson & Carter, 2010). Other studies have employed blindfolded throwing tasks to limit intrinsic feedback (Chiviacowsky & Wulf, 2007; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Chiviacowsky, Wulf, Medeiros, Kaefer, & Wally, 2008). As with the sequential timing tasks, participants need augmented feedback for learning to occur. In these tasks, participants are

blindfolded and asked to throw some object (e.g., beanbag) toward a target. Feedback is provided with a qualitative report of where the object lands with respect to the center of the target (e.g., "long and right"). Results from such studies have been similar to those from sequential timing studies: Learners who are allowed to control when feedback is presented perform more accurately in a no-feedback testing condition than those who are not given control over the presentation of feedback (Chiviacowsky et al., 2008a).

Rather than artificially limit intrinsic feedback, some researchers have investigated self-control over KR in tasks where some intrinsic information is available. In such situations, it is expected that augmented feedback would either allow participants to acquire a skill at a higher level than could be accomplished without feedback or serve to hinder learning (Magill, 1994; Magill, 2001). Research by Huet and colleagues provided support for both scenarios. An investigation of the effects of self-controlled concurrent feedback revealed that learners who were given control over the presentation of trajectory information while learning a flight simulator task performed more accurately in testing than participants not given control (Huet, Jacobs, Camachon, Goulon, & Montagne, 2009). A similar study investigated two forms of concurrent feedback during the learning of a virtual reality task requiring participants to adjust their walking speed to successfully pass through sliding doors. One group of participants was provided control over the presentation of error information in the form of a visual gauge. Another group was provided the information in the form of a superimposed set of doors. While the group with control over the gauge outperformed the YK condition, the group with control over the superimposed doors did not (Huet, Camachon, Fernandez, Jacobs, & Montagne, 2009). The results demonstrated that, in some cases, self-control over certain types of augmented feedback does not confer a benefit compared to a yoked control condition. It has been argued

that learners will attend to experimenter presented augmented feedback even when it is detrimental to learning (Magill, 1994; Magill, 2001; Schmidt & Wrisberg, 2008) and Huet and colleagues' work suggests the provision of self-control is not necessarily a preventative measure against such behavior.

While the majority of research investigating self-control over feedback has allowed learners to control KR, some studies have investigated the effects of providing learners with control over KP (Davis, 2009; Janelle et al., 1995; Janelle et al., 1997; Zabala, Sanchez-Munoz, & Mateo, 2009). While the results from some of these studies have been similar to studies involving KR, the body of literature is still small and the effects have not been as consistent as those seen in KR research. Janelle and colleagues (Janelle et al., 1995) allowed participants to control the presentation of KP while learning an underhand golf ball toss to a target. Participants in the SC condition demonstrated superior performance in a no-feedback testing condition compared to participants in the YK condition. In an attempt to build on the finding, Janelle and colleagues (Janelle et al., 1997) later provided participants with KP and prescriptive instructions while learning a non-dominant, overhand tennis ball toss. Although the primary learning goal was focused on throwing form, participants in the SC condition outperformed participants in the YK condition in both form and accuracy during delayed, no-feedback testing. This study is particularly important because it showed that benefits of self-control apply to learning a complex, multiple-degree-of-freedom movement. Attempts to identify a clear self-controlled KP benefit for real-world tasks, however, have produced mixed results. In one study allowing participants to access video and verbal KP while learning an Olympic squat, no significant benefits were found for controlling the presentation of feedback (Davis, 2009). In a study examining the learning of a basketball set shot (Aiken, 2011), access to video KP did lead to a

self-control benefit in form scores but not accuracy (Aiken, 2011). Finally, a field study allowing BMX athletes to control video feedback about starting technique demonstrated that self-controlled KP had immediate and lasting effects for these highly skilled athletes (Zabala, Sanchez-Munoz, & Mateo, 2009). In summary, while some findings have suggested that KP may benefit learning in a way similar to KR in a self-control setting (Aiken, 2011; Janelle et al., 1995; Janelle et al., 1997), more research is needed to substantiate this notion.

In general, self-controlled feedback research has produced several findings that are consistent with what is known from the broader body of literature on augmented feedback effects. For example, the positive effects of reduced frequency of feedback demonstrated in experimenter-controlled situations (Winstein & Schmidt, 1990) fit well with findings from learner-controlled training environments, with self-controlled learners demonstrating high levels of learning despite low levels of feedback requests (Janelle et al., 1995; Janelle et al., 1997; Chiviacowsky & Wulf, 2002). Although some studies have reported relatively high of feedback request frequencies (e.g., Chen, Hendrick, & Lidor, 2002), these are atypical. Other self-controlled feedback studies have offered additional support for the idea that augmented feedback can at times be detrimental to learning (Magill, 1994; Magill, 2001). Despite the evidence that learners may be in the best position to know when they prefer or need feedback (Chiviacowsky & Wulf, 2002), there is also evidence suggesting they will sometimes actively choose to receive detrimental feedback if it is available (Huet et al., 2009a). This finding demonstrates the importance of providing learners with the types of feedback that have been shown to best facilitate learning for a given task.

Self-controlled feedback research has also produced some findings that challenge traditional ideas about feedback, particularly those centered on the informational properties of

feedback. The traditional view of augmented feedback is that it functions to provide learners information about errors so that they can make corrections during subsequent attempts (Schmidt & Lee, 2011; Schmidt & Wrisberg, 2008). Some self-controlled feedback studies, however, have shown that learners actually prefer to receive feedback after so-called good trials (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005). In addition, learners' stated preference for feedback after good trials has been supported by statistical comparisons showing superior performance on feedback trials compared to no-feedback trials (Chiviacowsky & Wulf, 2002). These studies indicate that participants not only prefer to receive feedback when successful, they actually have the capability to distinguish between "good" and "bad" performance, even when intrinsic information is severely limited. To test this notion further, Chiviacowsky & Wulf (2007) systematically provided feedback to participants after either "good" or "bad" trials, and found a learning benefit for "good"-trial KR compared to "bad"-trial KR. Questionnaire results from self-control studies have also shown that learners may actually prefer to receive feedback when their performance is most accurate, not least accurate (Chiviacowsky & Wulf, 2002; Chiviacowsky & Wulf, 2005; Fairbrother, Post, Laughlin, & Alami, 2011). In their 2002 study examining the effects of self-control over KR while learning a sequential timing task, Chiviacowsky and Wulf administered a post-training questionnaire to both self-control and yoked participants. Of the 15 SC participants, 10 reported that they asked for feedback primarily after what they thought were good trials. Additionally, 7 of 11 of the yoked participants reported that they would have preferred to receive feedback after good trials (Chiviacowsky & Wulf, 2002). In another investigation of self-control over KR while learning a sequential timing task, Patterson & Carter (2010) found that 67% of self-control participants reported asking for feedback after good trials while 57% of yoked participants reported that they would have

preferred to receive feedback after good trials (Patterson & Carter, 2010). Participants in self-control studies have done more than simply express a desire for feedback after good trials. Chiviacowsky and Wulf analyzed timing errors in sequential key pressing tasks and found that participant performance was more accurate on trials for which feedback was requested than on trials when feedback was not requested (Chiviacowsky & Wulf, 2002). It seems that participants not only prefer to receive feedback when their performance is successful but they are also able to develop a sense of success even in a task where intrinsic information is severely limited (Chiviacowsky & Wulf, 2002). These findings, in combination with the reports of extremely low request frequencies, have caused some researchers to question the emphasis traditionally placed on informational aspects of feedback and argue that research should focus more on the potentially important motivational aspects of feedback (Chiviacowsky & Wulf, 2007).

It is important to note that this preference for feedback after good trials has been reported primarily in studies investigating the effects of providing KR when intrinsic information is limited. In a study that investigated the effects of providing learners with control over video KP while learning a basketball set shot, preferences for feedback after good trials were not nearly as pronounced (Aiken, 2011). Self-control participants reported asking for feedback occasionally after both good and poor trials. In addition, virtually equal numbers of yoked participants expressed a desire for feedback after good ($n = 6$) and poor ($n = 8$) trials. Self-control participants also reported requesting feedback to confirm both correct and incorrect form or to simply evaluate performance (Aiken, 2011). Aiken (2011) speculated that, with the complexity of information available in video KP, distinguishing between good and bad trials might not have been a simple task (Aiken, 2011). These results highlight the need for future research exploring feedback preferences when learners are allowed to control the presentation of KP.

Practice organization. Much like feedback, experimenters have typically controlled practice organization in previous motor learning studies. Evidence exists, however, to suggest that allowing participants to control practice organization may produce learning benefits. Titzer, Shea, and Romack (1993) examined the effects of allowing learners to control the order of practice while learning three movement patterns in a barrier knockdown task. A group of learners provided with self-control over the order of their practice was compared to a group using a blocked practice schedule (i.e., participants performed all trials of a pattern before moving to the next pattern) and a group using a random practice schedule (i.e., participants performed the three different patterns randomly and were never presented with the same task twice in succession). During an immediate retention test, self-control participants demonstrated significantly faster reaction times than the blocked participants and significantly faster movement times than both the random and blocked participants. In a 24-hour retention test, self-control and random groups performed with fewer errors than blocked participants. Because Titzer and colleagues failed to include a yoked condition, however, it was unclear whether learning benefits existed because of self-control, per se, or because participants happened to choose advantageous schedules of practice (Wu, 2007). Keetch and Lee (2007) addressed this issue by adding a yoked condition to an investigation of participants learning a mouse-pointing task. Results indicated that the self-control condition did not suffer a decrement in performance when moving from acquisition to retention while the yoked control group did. Although this study did not provide direct evidence of a self-control benefit when comparing group performances during retention testing, it did suggest that the provision of self-control over practice schedule does have the potential to influence learning in positive ways. A similar study by Wu & Magill (2011) provided more compelling evidence by comparing self-control and

yoked groups learning three sequential key-pressing patterns. Self-control participants, who were allowed to choose the order in which they practiced the patterns, performed with significantly less error on a transfer test than did yoked participants. Although only a few studies have examined the topic, the available results suggest that control over the schedule of practice may provide learning benefits.

Amount of practice. To date, only one study has examined the effects of allowing learners to self-control the amount of practice they complete. In an effort to determine if self-control effects generalized to aspects of training that did not directly alter task-relevant information available on a trial-to-trial basis, Post, Fairbrother, and Barros (2011) allowed learners to decide how many trials to complete while learning a dart-throwing task. Self-control participants performed with more accuracy in transfer testing than did yoked participants. In addition, self-control participants recalled the number of trials they practiced with significantly more accuracy than yoked participants, suggesting higher levels of engagement with the task. The results of this study suggest that self-control benefits are due at least in part to the provision of control itself and are not just a consequence of the fact that such control allows learners to manipulate task relevant information during practice.

Model presentation. Two studies have examined learners' control of the presentation of a model demonstration during skill learning. Both produced results consistent with other observations of a self-control benefit for learning. Wrisberg and Pein (2002) examined the effects of allowing learners to control the schedule of model presentation while learning a long serve in badminton. Self-control participants were compared to a no-demonstration control group and a 100% demonstration group (i.e., demonstrations before every trial). In retention testing, the self-control group performed similarly to the 100% group, despite requesting demonstrations on

less than 10% of the trials. Although there was no yoked control condition, the results pointed to the efficiency of a self-controlled demonstration in reaching a similar level of proficiency as a more traditional demonstration approach. In a follow-up study, Wulf, Raupach, and Pfeiffer (2005) added a yoked control group to the design and examined participants learning of a basketball free throw shot. Participants with control over model demonstration demonstrated significantly better form scores during retention testing compared to YK participants, thereby providing clear evidence for a learning benefit from providing self-control over model demonstration.

An interesting contribution to the feedback literature has also been made by self-control studies that do not provide control over model presentation to learners. For some skills, the presence of a demonstration may eliminate the need for augmented feedback (Magill, 2001). Control over the presentation of an expert model has been shown to produce learning even without any additional augmented feedback (Wrisberg & Pein, 2002; Wulf, Raupach, & Pfeiffer, 2005). Although these studies have not directly addressed feedback, they do offer additional support for the idea that augmented feedback is not always necessary for learning to occur (Magill, 1994; Magill, 2001; Wrisberg & Schmidt, 2008).

Physical assistance devices. Guidance techniques are sometimes used when teaching motor skills, particularly with injured populations or when the skills involved may be dangerous. For example, individuals could be provided access to handrails while learning to walk in a rehabilitation setting. The ultimate goal is to move without any assistance, but assistance during training provides both safety and psychological support. In an effort to discover whether self-control effects might extend to guidance, Wulf and Toole (1999) examined the effects of self-control over the use of a physical assistance device during learning of a ski simulator task. Self-

control participants were allowed to request the use of poles during two days of practice prior to a no-pole retention test. In retention tests, the self-control group outperformed a yoked group. The authors speculated that control over the physical assistance provided by the poles may have allowed self-control participants to experiment with different tactics and strategies. Hartman (2007) extended this line of research with an examination of the effects of control over physical assistance devices while learning a dynamic balance task (i.e., stabilometer). Consistent with the findings from Wulf and Toole, the self-control group produced a higher performance during retention than participants in a yoked condition. Interestingly, pilot studies had previously demonstrated that the physical assistance devices had no effects on learning. Consequently, the authors argued that SC participants' perception of control may have been enough to produce learning benefits (Hartman, 2007).

Self-control effects in different populations. Several researchers have examined whether self-control effects can be generalized to various populations. Fairbrother, Laughlin, and Nguyen (2011) examined the effects of self-control over KR in active and sedentary individuals learning a beanbag-tossing task. Although the active condition was more accurate than the sedentary condition, both benefited from the provision of self-control when comparing their transfer performance to that of yoked control groups. Benefits of self-control have also been demonstrated in children. Chiviacowsky and colleagues (Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008) examined the effects of self-control over KR in 10-year old children learning a beanbag-tossing task. Children provided with control over the presentation of KR performed more accurately in retention testing than children given feedback according to a yoked schedule. Sanli & Patterson (2009) also found benefits for children in a study that examined the effects of providing self-control over the order of repetitions when learning three novel spatiotemporal

patterns. Children given self-control over order performed more accurately during retention testing than children who followed a yoked schedule. Finally, self-control effects have been demonstrated in adults with Parkinson's disease. Chiviacowsky, Wulf, and Lewthwaite (2011) examined the effects of providing control over physical assistance devices while learning a stabilometer task. Similar to other studies, self-control participants demonstrated more effective learning than yoked participants.

Self-Control and Realistic Training

Despite repeated calls to study more realistic tasks (Martens, 1987; Wulf & Shea, 2002), self-control studies have largely involved artificial tasks and/or an artificially created need for assistance. Indeed, the most compelling evidence for self-control effects has come from studies that have employed traditional methods of examining feedback effects: Participants are required to learn novel tasks in situations where intrinsic information is virtually non-existent. The results of such studies have been remarkably consistent: Participants allowed to control some aspect of training tend to perform better during delayed testing (e.g., 24-hours) than participants not given that control (Chen, Hendrick, & Lidor, 2002; Chiviacowsky & Wulf, 2002; Chiviacowsky, Wulf, & Lewthwaite, 2011; Chiviacowsky, Wulf, Medeiros, Kaefer, & Tani, 2008; Hansen, Pfeiffer, & Patterson, 2011; Patterson & Carter, 2010; Wulf & Toole, 1999). The majority of self-control studies have provided some augmented form of assistance (e.g., KR, physical assistance) using laboratory tasks (e.g., sequential key-pressing). In most cases, tasks have been specifically designed for study purposes (e.g., Chiviacowsky & Wulf, 2002). In other cases, participants have been required to perform actual real-world skills (e.g., throwing) in a novel fashion (e.g., with the non-dominant hand) (Janelle et al., 1997). A handful of studies have not only involved arbitrary task demands (e.g., non-dominant hand, blindfolded), but also limited sources of

intrinsic feedback (e.g., Fairbrother, Laughlin, & Nguyen, 2011). Despite the understanding that KP is more useful than KR in real-world tasks, most self-control research has focused on manipulating KR using arbitrary laboratory tasks (Salmoni, Schmidt, & Walter, 1984; Wulf, 2007). A key assumption this research is that learners will behave in these types of artificial environments similarly to how they behave when learning real-world tasks in ecologically valid settings (Schmidt & Lee, 2011). This assumption appears to be a tenuous one and in fact some evidence suggests the opposite is true (Wulf & Shea, 2002).

Attempts to provide self-control for more realistic tasks, however, have produced mixed results. Studies examining the learning of tasks such as weight lifting and golf putting have failed to demonstrate a self-control benefit (Davis, 2009; Wu, 2007). Studies examining basketball shooting and badminton long serves have shown self-control effects in one measure but not another (Aiken, 2011; Wrisberg & Pein, 2002). Additionally, previous self-control research has shown little resemblance to realistic training environments with respect to the amount of control afforded participants. To date, few efforts have examined the effects of providing learners with control over more than one aspect of practice (Aiken, 2011; Davis, 2009; Jones, 2010; Post, Fairbrother, Barros, 2011). Davis (2009) offered participants a choice of either a video demonstration or verbal instruction while learning an Olympic squat. Jones (2010) allowed participants to control both the schedule of practice and feedback presentation while learning three sequential timing tasks. In addition to the primary aspect of control, Aiken (2011) and Post et al. (2011) allowed learners to control their pacing of trials and access to instructions, respectively. The Davis and Jones studies both failed to find self-control effects. Interestingly, however, both Aiken and Post et al. provided some indication that self-control and yoked groups differ in how they use the secondary aspect of control during practice.

Explanations for Self-Control Effects

In the earliest self-control studies, Janelle and colleagues (1995; 1997) offered several potential explanations for self-control effects: Deeper information processing; increased confidence from control over learning; increased motivation; and the development of better learning strategies. In subsequent studies, researchers continued to speculate about the mechanisms underlying self-control effects. Explanations included increased intrinsic motivation (Chen, Hendrick, & Lidor, 2002; McNevin, Wulf, & Carlson, 2000) or an increased sense of control over the learning environment (Wulf & Toole, 1999). Chiviacowsky and Wulf (2002) proposed that self-control may benefit learning because it allows participants to tailor the environment to their specific needs and preferences. In their study, participants preferred to receive feedback primarily after good trials, which Chiviacowsky and Wulf (2002) interpreted as an indication that self-controlled practice schedules were more in accordance with the participants' needs and preferences. Additionally, they suggested that motivational factors associated with the preference for good feedback may have contributed to the benefits demonstrated for participants afforded self-control. Despite speculation, few researchers have attempted to directly explore possible explanations for self-control benefits. In part, the vagueness of explanations for self-control effects makes any direct inquiry difficult (Chiviacowsky & Wulf, 2002). The explanations often rely on constructs being examined (e.g., motivation and engagement) that are difficult to measure and are not often assessed in typical motor learning studies. In addition, standard self-control designs (i.e., SC and YK) may not be best suited for understanding the mechanisms underlying the learning effects. Researchers have speculated about the potential reasons for self-control effects. The way forward may be to identify the best method of investigating each explanation.

The body of research in self-control has established the potentially powerful effects of allowing learners to exert some control over the training environment. The effects have extended across many dimensions of practice (e.g., feedback presentation and practice schedule) and been demonstrated in many populations of learners (e.g., children and adults). Results from self-control studies have both reinforced traditional ideas about motor learning concepts (e.g., faded frequency of feedback as beneficial for learning) and challenged researchers to re-evaluate long held beliefs (e.g., preference for feedback after error trials when given self-control). In summary, self-control research suggests that, in many instances, learners may be in a privileged position of knowing both what assistance they need and when they need it. The current body of research, however, is somewhat limited by a lack of ecological validity. Exploring self-control in more realistic training settings may provide more insights into the possible mechanisms producing the benefits observed in previous studies and perhaps identify possible limitations of allowing learners to control the practice setting.

Self-Control and Self-Regulation

In the earliest self-control studies in the motor domain, Janelle and colleagues (Janelle, Singer, & Kim, 1995; Janelle et al., 1997) drew upon previous research in self-regulation to provide a rationale for giving individuals control over KP during learning. However, subsequent research in the field of motor behavior has viewed self-regulation as more or less synonymous with giving learners control over some aspect of training environment (Bund & Wiemeyer, 2004). Because the conditions of practice are a primary focus in motor behavior, a more narrow view of self-regulation seemed to make sense. By investigating self-regulation through the lens of control, a multitude of studies have revealed the value of a very important idea: allowing learners some control over the practice environment enhances learning by allowing learners to

self-regulate more effectively compared to participants who are not provided such control. This phenomenon is particularly important because it runs counter to many traditional notions of motor skill instruction in therapy and sport settings. In most sport and rehabilitation settings, learners are told exactly what to do and when to do it. In addition, they are provided with feedback when the coach, instructor, or therapist feels it is necessary. Feedback is usually given after unsuccessful attempts to offer corrective information. The body of work on self-control effects in the motor domain, however, suggests that learners may be in a privileged position to know when they need feedback and may actually prefer it after successful trials (Chiviacowsky & Wulf, 2002; Fairbrother, Post, & Laughlin, 2010).

Simply giving learners control over a learning environment, however, does not ensure that they will perform as self-regulated learners. In initial studies, learners may have possessed the self-regulation abilities necessary to demonstrate learning when presented with relatively simple motor skills. Giving learners control, then, may not have produced self-regulation as much as it allowed it to be expressed. Support for this notion comes from a study that investigated the effects of giving 10-year old children control over feedback presentation while learning a timing task. In that study, learning was dependent upon the frequency of feedback. Children who asked for less feedback (i.e., on 8.4% of trials) demonstrated less learning than those who asked for more feedback (i.e., on 39.3% of trials) (Chiviacowsky & Wulf, 2008). It is possible that those children who had more advanced self-regulation skills were able to use the feedback more beneficially and therefore asked for it at a significantly higher rate than those who possessed less advanced self-regulation skills. Such an explanation would be consistent with research suggesting that training in self-regulation skills may be necessary to take advantage of

self-control opportunities in a practice setting (Cleary & Zimmerman, 2001; Cleary, Zimmerman, & Keating, 2006; Kitsantas, Cleary, & Zimmerman, 2000).

In discussing their original findings, Janelle et al. (1997) urged future researchers to continue to explore the interplay of self-control with self-regulatory skills in an effort to better understand the mechanisms underlying the learning advantages seen in groups given more control over their own skill acquisition. They more specifically suggested that self-efficacy – a key component in Zimmerman's (1989) framework of self-regulation – may play an important role in self-control effects. In theory, self-control should contribute to greater confidence in the ability to successfully perform the task. This confidence, represented in higher levels of self-efficacy, should in turn facilitate subsequent learning.

Bund & Wiemeyer (2004) directly addressed the relationship between self-control and self-efficacy. Traditional SC and YK groups were compared while attempting to learn a forehand stroke in table tennis. Additionally, self-efficacy was assessed at five different points during acquisition and retention testing. While both groups increased in self-efficacy across acquisition and retention, the SC group reported significantly higher levels of self-efficacy than their YK counterparts. The results suggested the learning benefits seen in self-control studies may at least in part be due to enhanced self-efficacy of SC participants. Aside from Bund & Wiemeyer , however, no other studies have attempted to directly address the possible associations between self-control and self-regulatory behaviors such as task clarification, goal generation, and the use of learning strategies. Despite being grounded in self-regulation research, self-control studies have primarily focused on issues surrounding feedback and practice organization. To gain a better understanding of the mechanisms beneath self-control effects, however, the current conception of self-control within motor learning may need to be expanded. Accordingly, there

remains the need to gain a broader understanding of the behaviors and characteristics of participants learning motor skills in a self-control protocol.

Conclusion

Despite being grounded in ideas about both feedback and self-regulation, self-control studies have predominantly mirrored feedback research and other traditional approaches to examining motor learning. While this research has been instrumental in demonstrating the benefits of allowing individuals to control some aspect of their learning environment, it has also limited our understanding of the behaviors and individual characteristics that might play a role in producing these benefits. Because participant choice has been largely restricted to one type of instructional assistance and presented in a dichotomous yes-or-no fashion, there exists a lack of understanding as to what it means to self-regulate one's engagement within a motor learning protocol. Self-regulation research in general and Zimmerman's (1989) work in particular provides an alternate framework for studying self-control behaviors in motor learning. The purpose of this study, therefore, was to examine self-control behaviors in a more realistic learning environment than those used in previous studies. Specifically, participants were given control over multiple types of instructional support in much the same way individuals experience it in the real world. This approach combines the tradition of research in self-regulation with a design incorporating elements identified in motor learning research as important to skill acquisition. Among other things this combination should offer greater insight into the process of self-regulation in motor learning and provide direction for future research attempting to discover the underlying mechanisms of self-control benefits.

CHAPTER 3

Method

Participants

The present study included 20 undergraduate students (11 women, 9 men; M_{age} = 18.8 years; age range: 18-22 years) who were recruited from a participant pool managed by the university. None had prior experience with juggling. All participants acknowledged their voluntary participation by completing an informed consent (see Appendix A), which had been approved by the University of Tennessee Institutional Review Board (IRB #8676B).

Task and Apparatus

Participants were required to learn a 3-ball cascade juggle using juggling balls that were 6 cm in diameter and 105 gr in weight. While practicing, participants were required to remain standing within a circular region that had a diameter of 60 cm. Participant practice sessions were filmed using a Kodak Zx1 (Rochester, NY) digital camcorder.

Procedure

Upon arriving at the laboratory, participants completed an informed consent statement indicating their voluntary participation in the study and verbally confirmed that they had no previous experience with juggling. They were then told that their goal over the course of the week was to learn to juggle and master the skill to the best of their ability. They were given a description of the 3-ball cascade juggle and shown a live demonstration of the task. Participants then were given one attempt to perform the 3-ball cascade juggle. After this attempt, participants completed an assessment of self-efficacy with respect to the task (see Appendix B).

After reporting their self-efficacy, participants were told that they would have access to four types of instructional assistance (IA) during their training: (a) Instructions (I); (b) video

demonstration (D); (c) verbal feedback about their technique (KP); and (d) verbal timing information about the duration of a juggling attempt (KR). Instructions consisted of a minute-long slideshow with still photographs and verbal directions highlighting key features of successful juggling. The video demonstration consisted of a video clip of a skilled performer completing two juggling cycles (i.e., 12 throws and 12 catches). Verbal feedback about technique highlighted the most critical error in the participant's technique. Timing information was provided as the total amount of elapsed time in seconds from the moment the first ball was tossed until one of the balls hit the floor or the participant caught a ball to intentionally stop the juggling cycle. Participants were informed that they would have access to the four forms of assistance during their practice sessions but that assistance would only be given when they requested it. They were also informed that they would be tested on the fifth day of the study and that they would not have access to any assistance during testing.

After participants were introduced to the task and the four types of IA, they began the acquisition phase of the study. Acquisition consisted of four days of practice sessions that lasted 45 minutes each. During these sessions, participants were required to complete each attempt using all 3 juggling balls, but were allowed to choose the pace of practice. They were informed that an attempt began when they threw the first ball and ended when the juggling pattern broke down for any reason (i.e., dropped balls, voluntarily termination, or leaving the circular region). They were also told that there was no limit to the number of attempts they were allowed during each 45-min practice session, but that they would be given only a set number of attempts during the test on the fifth day of the study.

During acquisition, participants completed additional self-efficacy assessments when certain performance milestones were achieved. If a participant successfully completed one cycle

of juggling (i.e., 6 throws and 6 catches), he or she was stopped and prompted to complete a self-efficacy assessment. If a participant achieved two cycles of juggling, he or she was again prompted to complete a self-efficacy assessment. Participants were informed that these assessments were the only time when the researcher would stop them or give them any indication of progress. Outside of these assessments, the researcher would only intervene when a participant asked for instructional assistance.

On the final day of acquisition, participants completed a post-training interview about their experience during the practice phase (see Appendix C). The interview included questions about how participants used the four types of instructional assistance as well as the use of strategies and goals during their practice sessions. The interview was based on the post-training questionnaire used by Chiviacowsky & Wulf (2002) but included the addition of Likert-type rating scales and open-ended questions. These interviews took approximately 10 min and were audio recorded for later transcription.

Participants returned on the fifth day for retention and transfer testing. During testing, participants were not allowed to ask for any assistance and were not given any information about their performance. The duration of attempts was capped at 60 s, so some of the more proficient jugglers who went the entire 60 s did receive an indication of how long they juggled. The retention test consisted of 10 attempts with the same juggling balls used in practice. After the retention test, participants were immediately informed that they would also complete 10 attempts with a different set of juggling balls that were the same size as those used during acquisition and retention but different weights. Two of the balls were heavier than those used in practice and one was lighter. Just before the transfer test, participants completed a final self-efficacy assessment to gauge their confidence with respect to juggling with a different ball set. Participants then

completed 10 juggling attempts. After the transfer test, participants were allowed to see information detailing their performance during the testing phase of the study and were provided answers to any questions they had about the study.

Data Treatment and Analysis

Data included both quantitative and qualitative measures of participant behaviors, strategies, goals, and juggling performance. Primary dependent variables for juggling performance included number of catches and number of attempts. Self-efficacy assessments were administered up to four times for each participant: (a) Prior to practice; (b) upon achieving a 6-catch trial, (c) upon achieving a 12-catch trial, and (d) prior to transfer testing. For the post-training interview, data were collected for participant ratings on the Likert-scale items and verbal responses were collected for open-ended responses. In addition, practice-related participant behaviors during acquisition were tabulated from the video record (e.g., self-talk statements).

Juggling performance. The number of consecutive catches was recorded for each juggling attempt. The consecutive catch count began when a participant tossed the first ball and ended when a ball was dropped, when a participant voluntarily stopped the trial, or when a participant moved outside of the designated area. In addition, the total number of catches and the total number of practice attempts during acquisition were recorded. The primary performance measure was catches per attempt, which was calculated for each day of acquisition, retention, and transfer. Participants were divided into performance groups based on mean catches per attempt during retention testing. These groups were based on criteria established in previous research addressing automaticity and 3-ball cascade juggling (Bebko et al., 2003). Participants who averaged greater than 20 catches per attempt during retention or transfer were categorized as *proficient learners*. Those who averaged between 4 and 20 catches per attempt were categorized

as *emerging learners*. Those who averaged less than 4 catches per attempt were categorized as *late learners*. Group means were calculated for each day of acquisition, retention, and transfer.

Requests for IA. Requests for IA were recorded for individual participants during the four days of acquisition. Participant requests were tracked by day of practice and type of assistance requested. Because total attempts varied by participant, daily percentages of requests were used for comparisons. For each day of practice, request percentages were calculated by dividing request counts for each type of assistance by the number of attempts. Individual percentages were used to calculate group means. The overall percentage of requests was calculated by dividing participants' total number of requests for assistance by their total number of attempts. Individual percentages for total requests were used to calculate the mean overall percentage of requests.

Self-efficacy. Self-efficacy was measured by tabulating participant responses to up to four self-efficacy assessments throughout the study. For each assessment, participants rated their confidence to successfully juggle for increasing durations of time. The resulting score was between 0 and 100, with 0 indicating certainty that the participant could *not* juggle for longer than 5 s and 100 indicating certainty of success in juggling for longer than 60 s. Every participant completed an assessment prior to acquisition and just prior to transfer testing. During acquisition, 16 participants also completed assessments upon successfully reaching the predetermined criteria of completing one juggling cycle (i.e., 6 throws and 6 catches) and 13 completed assessments upon successfully completion of two juggling cycles. Individual scores at each testing point were used to calculate group means for self-efficacy.

Post-training interview. Participant interview responses were used to describe participant preferences for IA and related self-regulatory behaviors (e.g., goals and strategies). Participants responded to questions on a 5-point scale (1 = *never*, 2 = *seldom*, 3 = *occasionally*, 4 = *often,* and 5 = *always*). Participants rated how often they used instructions and demonstrations for guidance and correction. They also rated how often they asked for KP and KR after good and bad attempts. In addition, participants were asked open-ended questions about their use of the four types of assistance. They were also asked to describe any goals and/or strategies they employed while practicing. Participant ratings were used to calculate group and overall means. Responses to the open-ended questions were reviewed and categorized into themes based on similarity. A second reader provided agreement on this classification. In addition, interview responses were evaluated to determine if they were consistent with performance and request data.

Behavioral observations. Participant behaviors were recorded throughout practice. These behaviors included self-talk statements as well as behaviors that indicated rehearsal. This information was used to offer additional insight and support for descriptive accounts of performance, use of IA, and reports of self-efficacy. Because of the nature of the study and small size of the resulting performance groups, the focus of data analysis was on exploration and description. Qualitative descriptions and performance data were examined concurrently to identify emerging themes and present a composite depiction of participant behaviors that could be interpreted within the theoretical framework of the study.

CHAPTER 4

Results

Only summary data and group comparisons are reported in this chapter. Complete acquisition, retention, and transfer data are available in Appendix D.

Juggling performance

Table 1 displays performance data for all participants sorted by performance group and includes daily practice means. Figure 1 depicts the progression of performance in acquisition, retention, and transfer. Participants were divided into three performance groups based on retention and transfer performance, using the criteria set forth by Bebko et al. (2003). Six participants were categorized as *late learners*, eight as *emerging learners*, and six as *proficient learners*. Although the total number of juggling attempts and total catches varied substantially within each group, this categorization effectively illustrated certain important performance patterns. The variability in attempts and catches was in part due to the fact that participants controlled the pacing of attempts and attempts generally increased in duration as juggling skill improved. Consequently, lower skilled participants sometimes generated substantially larger numbers of attempts compared to their more skilled counterparts.

Late Learners. Participants who averaged less than four catches per attempt during retention and transfer were categorized as Late Learners (LL). The average acquisition performance was 1.3 catches per attempt (*SD* = 0.6) with individual performances ranging from 0.5 to 2.1. The average retention performance was 2.0 catches per attempt (*SD* = 1.1) with individual performances ranging from 0.6 to 3.6. The average transfer performance was 1.6 (*SD* = 0.9) with individual performances ranging from 0.4 to 2.8. LL performance was characterized

by a lack of improvement over the course of acquisition, retention, and transfer testing. The LL group averaged 971.2 total juggling attempts during practice (*SD* = 428.0) with individual participant attempts ranging from 385 to 1,565.

Emerging Learners. Participants who averaged between 4 and 20 catches per attempt during retention or transfer were categorized as Emerging Learners (EM). The average acquisition performance was 3.7 catches per attempt (*SD* = 1.1) with individual performances ranging from 2.3 to 5.7. The average retention performance was 7.4 catches per attempt (*SD* = 2.6) with individual performances ranging from 3.4 to 10.8. The average transfer performance was 6.9 catches per attempt (*SD* = 2.2) with individual performances ranging from 4.7 to 9.7. EM performance was characterized by a steady improvement in performance over the first three days of acquisition and a leveling off on the final day. The EM group averaged 922.4 total juggling attempts during practice (*SD* = 253.0) with individual participant attempts ranging from 703 to 1,399.

Proficient Learners. Participants who averaged more than 20 catches per attempt in retention or transfer were categorized as Proficient Learners (PR). The average acquisition performance was 13.1 catches per attempt (*SD* = 8.1) with individual performances ranging from 4.5 to 25.2. The average retention performance was 68.7 catches per attempt (*SD* = 40.5) with individual performances ranging from 20.9 to 119.5. The average transfer performance was 30.4 catches per attempt (*SD* = 16.3) with individual performances ranging from 4.8 to 46.9 (*M* = 68.7, SD = 40.5). PR performance was characterized by a rapid improvement in performance that persisted throughout acquisition and retention testing, with a decrement upon moving to transfer.

The PR group averaged 545.3 total juggling attempts during practice (*SD* = 314.1) with individual participant attempts ranging from 284 to 1,134.

Requests for IA

Overall request percentages. Figure 2 depicts the pattern of request percentages for all types of IA for all participants throughout practice. Total number of requests as a percentage of total attempts varied greatly by participant and ranged from 0.6% to 12.3%. The mean percentage across all participants was 3.7% (*SD* = 3.8%). Requests decreased from the first day to the second day, increased on the third day, and reached their highest levels on the final day. Total request patterns differed by performance group, however. Table 2 displays request percentages sorted by performance group. Figure 3 depicts the pattern of requests for each group across the four days of acquisition. The request pattern for the PR group (*M* = 6.0, *SD* = 4.3) was characterized by a relatively high request percentage that decreased during Day 2 before increasing slightly during Day 3 and then dramatically during Day 4. The request pattern for the EM group (*M* = 2.4, *SD* = 2.1) was similar to that for the PR group during Days 1-3, but did not show an increase during Day 4. The request pattern for LL (*M* = 3.0, *SD* = 4.4) showed a steady decrease in requests for assistance across all four days of acquisition.

Request frequencies by IA. Table 3 contains the total number of requests as a percentage of attempts for each type of IA throughout the four days of acquisition. Figure 4 depicts the pattern of requests for each type of IA across the four days of acquisition. Request percentages for I, D, and KP decreased steadily throughout practice while the request percentage for KR increased steadily. Participants had higher request percentages for KP and KR compared to instructions or video demonstrations.

Tables 4-7 contain request percentages for each type of IA sorted by performance group. Figure 5 depicts the patterns of those requests for each performance group. Request patterns for instructions, video demonstration, and KP were similar for all performance groups, generally showing declines in request percentages throughout acquisition. Request patterns for KR differed by group, however. KR requests by the LL group did not increase because only two participants in the group were able to approach the threshold for receiving KR (i.e., 3 seconds of juggling). KR requests by the EM group increased across Days 1-3 of practice and then decreased slightly on Day 4. This pattern corresponded with a plateau in performance. KR requests by the PR group increased slightly across Days 1-3, followed by a dramatic increase during Day 4.

Preferences for IA. A portion of the post-training interview allowed participants to rate their preferences for IA on a 5-point scale (1 = *never*, 2 = *seldom*, 3 = *occasionally*, 4 = *often*, and 5 = *always*). Table 8 contains the group means for participant responses to these questions. Group means were relatively similar so participant preferences will be reported in terms of overall preferences for all participants. Table 9 displays the total number of participants who indicated each response category for the questions regarding their preferences for IA. Most participants (i.e., 13 out of 20) reported using instructions for guidance or correction either *never* or *seldom*. In contrast, more participants indicated they used the video demonstrations *occasionally*, *often*, or *always* to provide guidance (n = 13) or correction (n = 12). Participants were fairly split in terms of their responses regarding their requests for KP after good performances, with 11 indicating *never* or *seldom* and 9 indicating *occasionally*, *often*, or *always*. In contrast, almost all participants (i.e., 19 out of 20) reported asking for KP after bad performances *often* or *always*. Participant responses about KR use indicated a strong preference for KR after good performances. Twelve participants indicated that they *always* requested KR

after good performances and the remaining eight participants reported requesting KR after good performances either *occasionally* or *often*. None of the participants reported asking for KR after bad performances either *often* or *always* and only two indicated they did so *occasionally*. Sixteen participants indicated they *never* requested KR after bad performances and two indicated they asked for it *seldom*.

Participants were also given the opportunity to respond to open-ended questions about their use of IA throughout practice. Responses from participants who chose to describe their use were grouped into common themes. Table 10 contains these themes along with the total number of participants represented by the theme. Eight participants described their use of instruction as a strategy to gain a general understanding of the task. Two participants described using the instructions to obtain information that was not available from the other forms of assistance. Nine participants described their use of video demonstration. Six indicated selecting video demonstration because they preferred visual information to verbal instructions. Three participants explained that they used video demonstration to obtain specific information about some aspect of the task because it allowed them to focus on a single aspect of the task. Thirteen participants described their use of KP in greater detail. Ten participants described using KP to highlight errors. In some instances, participants described knowing that they were doing something incorrectly but were not able to identify the actual flaw in their technique. In other instances, participants described asking for KP as a method of identifying flaws that they might not be aware of. Sixteen participants described their use of KR in more detail. Most (i.e., 10 out of 16) described using KR to confirm improvement. Additionally, some participants explained that this confirmation was useful in setting new goals throughout practice. Three participants described using KR as a way to monitor how changes in their technique impacted ultimate

performance (e.g., how height of throws affected attempt duration). Finally, three participants described using KR as a method for directly increasing confidence or maintaining motivation.

Goal-Related Behaviors and Use of Learning Strategies

Another portion of the post-training interview allowed participants to describe their use of goals and strategies throughout practice. Responses were grouped according to common themes that emerged. Table 11 contains these themes along with the total number of participants represented by the theme. Nineteen of the 20 participants described setting some type of goal during practice. Eight participants described their goals in terms of some ultimate level of improvement (e.g., juggle for 30 s by Friday). Participants described this improvement in terms of both time and count. Seven participants described setting goals that were incremental in nature. These participants spoke of adjusting goals regularly to make an additional catch or throw or perhaps add an additional second to the duration of a juggling attempt. These participants referenced goals in terms of the next step rather than in terms of the ultimate goal for performance. Three participants described goals in terms of general improvement. They spoke of wanting to get better but did not reference any specific count or time. One participant defined his goal in terms of technique alone. Only one participant indicated that she did not set any goals during practice.

Sixteen of the 20 participants described specific learning strategies employed throughout practice. Some participants indicated using more than one strategy. Eight participants reported using strategies connected to attentional focus. Strategies that indicated an external focus of attention included counting tosses, tracking colors, and focusing on the sound of the juggling balls as they hit each hand. Strategies that indicated an internal focus of attention included self-

talk to direct hand movements and a focus on the feel of the overall pattern. Six participants indicated that their strategy involved trying to emulate the technique described in the instructions and performed in the demonstration. Some participants also described using KP to determine how successfully they were matching this technique. Five participants described their strategy in terms of practice structure. These participants described relying on physical repetition as their preferred method of learning the technique. In addition, some described breaking the juggling technique into specific parts and attempting to build the movement by segment throughout practice. Four participants indicated that they used no strategy during practice.

Self-Efficacy

Participants completed up to four self-efficacy assessments throughout the study. Each assessment resulted in a score between 0 and 100, with 0 indicating certainty that the participant could *not* juggle for greater than 5 s and 100 indicating certainty of success in juggling for greater than 60 s. All 20 participants completed an assessment prior the start of acquisition and just prior to transfer. Sixteen participants completed assessments upon achieving 6 consecutive catches and 13 completed assessments upon achieving 12 consecutive catches. Table 12 contains participant scores for each assessment and performance group means. Figure 6 depicts group patterns of self-efficacy throughout the study. Only 2 participants in the LL group achieved 6 consecutive catches. As a result, no data were available for a 12-catch assessment. All but one participant in the EM group achieved 12 consecutive catches. As a group, EM self-efficacy scores increased from pre-acquisition to the 12-catch assessment. Pre-transfer self-efficacy, while still higher than pre-acquisition scores, declined from the levels reported at 12 catches. All participants in the PR group completed all four SE assessments. The PR group reported increasing levels of self-efficacy throughout the study. Scores were similar to those of the EM

group at the 6- and 12-catch assessments, but were much higher during the pre-transfer assessment.

CHAPTER 5

Discussion

Despite the growing body of evidence suggesting the benefits of allowing individuals to control some aspect of the practice environment, little is known about the behaviors underlying the phenomenon. Researchers have offered a number of possible explanations, but the vagueness of the constructs involved and limitations of experimental design have made testing these ideas difficult. This study represented an effort to address self-control behavior in a more ecologically valid setting with the hopes of gaining new insights into potential explanatory mechanisms for self-control effects. All of the participants were afforded control over access to four types of instructional assistance while learning to juggle: instructions, video demonstration, feedback about technique (KP), and timing information about the duration of juggling attempts (KR). Participant behaviors were observed, performance was recorded and quantified, and interviews were conducted. Several results emerged that offer support for and further insight regarding previously observed self-control benefits. The findings also provide direction for future research efforts.

Overall Frequency of Requests for Assistance

During acquisition, participants asked for assistance on an average of only 3.7% of total trials. This percentage is lower than has typically been reported in the self-control literature. For example, Chiviacowsky and Wulf (2002) reported that participants requested KR on 35% of acquisition trials while learning a sequential timing task. Janelle et al. (1997) reported a request rate of 11.15% for participants with access to KP while learning an overhand throw. Wrisberg and Pein (2002) reported a similar rate of 9.8% for participants given access to video demonstration while learning the long serve in badminton. These previous self-control studies

have typically involved discrete tasks and one-day acquisition periods. Participants were given a limited number of trials and a limited time to learn a relatively well-defined skill. In the present study, however, participants were given a four-day acquisition period to learn a continuous skill. They were not restricted to a set number of attempts. Rather, they were told to practice for a set period of time each day and that they could structure their practice as they chose with respect to pacing and use of instructional assistance. Interestingly, the previous studies that provided learners with access to greater amounts of intrinsic feedback (e.g., Janelle et al., 1997) reported lower request rates. In contrast, many of the studies reporting higher frequencies (e.g., Chiviacowsky & Wulf, 2002) used tasks and procedures that made participants entirely dependent on augmented feedback. Although the instructional assistance available to participants in the current study seemed to enhance skill acquisition (at least for some participants), juggling does provide a relatively high amount of intrinsic feedback and thus can arguably be mastered without augmented feedback. Therefore, it might be presumed that requests for instructional assistance are always tied to some extent to the availability of intrinsic feedback, which would have important implications for practitioners interested in determining the best ways to support learners' acquisition of different types of tasks. The results of the current study suggest that examining differences in task demands might be a fruitful possibility for future researchers interested in exploring the relationship between request frequencies and self-control benefits.

Pattern of Requests for IA

Several previous self-control studies have shown reductions in request frequencies as participants moved through acquisition (e.g., Chiviacowsky & Wulf, 2002; Janelle et al., 1997; Wulf & Toole, 1999). In the current study, a different pattern emerged when looking at the total request rates for all four types of assistance. Although requests for assistance decreased initially,

they rebounded to their highest rates by the fourth day of acquisition. Moreover, the pattern of requests across acquisition appeared to be mediated by the proficiency level of learners. Only the LL group requested less assistance over the course of practice. The EM group requested assistance less early in practice but increased their requests on Days 3 and 4. While requests for assistance on the final day were slightly lower than on the third day they were still higher than on the first day. The PR group requested assistance less during the first two days of practice but increased their requests on the final two days. The PR group requested assistance on 13.4% of attempts on their final day of practice, which was more than twice the request rate of their initial practice session. Participants' interest in KR contributed the most to this trend of increased requests. Requests for instructions, demonstration, and KP decreased throughout practice for all three groups while KR requests increased throughout practice. These increases were most pronounced for the PR group.

Although the current connection between increased KR requests and increased proficiency at first seems contrary to research highlighting the learning benefits of faded frequencies of KR (e.g., Winstein & Schmidt, 1990), possible explanations for this pattern can be identified. Juggling is a complex skill. For complex skills, there is some evidence that higher frequencies of feedback requests are not detrimental to learning (Wulf & Shea, 2002). The most compelling explanation, however, may be that KR was not essential for learning in the present study. In some previous studies, participants were forced to use the information provided by KR to gauge their level of improvement and success (e.g., Chiviacowsky &Wulf, 2002), therefore the absence of KR would have prevented any learning from taking place. Moreover, participants in earlier studies were informed that they would only have access to KR during practice so there was an imperative to prevent over-reliance on that source of information. In the current study,

participants not only had access to other types of instructional assistance, they also received intrinsic feedback they could use to help them learn to juggle. KR was requested only later in practice and seemed to represent a means of confirming participants' own evaluations of performance improvements. Although KR provided additional information, this information was not essential for skill acquisition. Instead, participants reported that that they used KR primarily to enhance motivation. Accordingly, there was little risk of participants becoming dependent on KR. Indeed, the highest KR frequencies in this study were generally associated with the highest levels of proficiency.

The current results suggest that control over multiple types of assistance allows participants to utilize different sources of information at different stages of learning. The present design allowed the availability of useful inherent feedback while also permitting participants to isolate and take advantage of the motivational function of KR. Presumably, the designs used in most previous studies prevented clear distinctions regarding the different ways that participants might have been using instructional assistance. For example, when learning a sequential timing task (Chiviacowsky & Wulf, 2002), participants might have initially used KR to identify errors and guide them toward the correct pattern of movement. At that stage, KR would primarily serve as a source of information regarding the outcomes of responses (e.g., movement time of 900 ms). Later, as participants became more skilled, they might have requested KR less often because they were using it for a different function. Increasing KR frequency in this situation would increase the likelihood that it would be paired with a relatively poor performance, potentially undermining the motivational function that participants are seeking. Thus, participants might only ask for KR when they have a strong conviction that their performance is good. In the current study, however, the nature of the task allowed participants to readily monitor their own

progress so there was little danger that they would ask for KR after a poor performance. This reasoning is consistent with the participants' reports of using instructions and video demonstration early in practice to gain an understanding of the proper technique and using KP to identify flaws in their technique and monitor progress. Put simply, they appeared to use these three types of instructional assistance to gain information about how to execute the task. In contrast, participants reported using KR primarily as a means of enhancing motivation. Some participants made direct reports related to motivation and others indicated they used KR to confirm subjective evaluations of performance improvements and set new goals, both of which are arguably tied to increased motivation.

Thus, it appears that the results of the current study offer some support for previous speculation that participants use self-control to confirm success, which in turn contributes to enhanced motivation and further performance improvements. The findings also suggest that it may be valuable for practitioners to allow individuals to control those aspects of practice that allow participants to confirm successful performance. Future researchers might explore this relationship in more detail by providing access to informational forms of augmented feedback on a fixed schedule while allowing motivational forms of feedback to be controlled entirely by the participant. Exploring this relationship with SC and YK groups would possibly allow a better understanding of how motivational aspects of feedback relate to the learning effects demonstrated in previous self-control studies.

Preferences for IA

Previous self-control research has indicated that participants prefer feedback primarily after good performances (e.g., Chiviacowsky & Wulf, 2002; Fairbrother, Post, Laughlin, &

Alami, 2011). The current results are consistent with these findings with respect to KR. In the post-training interview, participants were asked to rate how often they requested KR after both good and bad attempts. A large majority (16 out of the 20) indicated they never asked for KR after bad trials while all 20 participants reported asking for KR after good trials at least occasionally. Participant preferences for KP, however, did not follow the same pattern and were not consistent with previous findings. In the present study, 19 of the 20 participants reported asking for KP often or always after bad attempts. Responses regarding KP requests following good attempts varied greatly, ranging from never to always. Although this pattern differs from most previous findings (e.g., Chiviacowsky & Wulf, 2002) it is consistent with the results of one study that provided participants with access to KP while learning a basketball set shot (Aiken, 2011). In that study, participants reported asking for KP after both good and bad trials and requests were split fairly evenly between the two. Thus, it is likely that the availability of intrinsic feedback regarding task outcomes may influence when and how participants use KP. Although some participants in the present study reported asking for KP after good trials, they all asked for KP after bad trials. Responses to the open-ended questions in the interviews indicated that KP was used to identify flaws in technique and monitor success in correcting those flaws. Given that perspective, it makes sense that all participants reported asking for KP after bad attempts. The participants who reported asking for KP after good attempts were typically among the more proficient jugglers and were therefore better able to use KP to confirm their success at correcting technique flaws. Those who did not develop the capability to correct their technique flaws were only able to use KP to identify mistakes.

The results of the present study offer additional insight into participant preferences for feedback and suggest that those preferences may be tied to the role that feedback serves as well

as the information it provides. Providing participants with access to both KR and KP provided a clearer understanding of when participants prefer certain types of feedback and why those preferences may exist. Previous research has largely provided only KR and participant preferences have been based on access to this source of outcome information. The current findings suggest that participants may not simply prefer feedback after good trials. Instead, participants may prefer feedback that is most relevant to their current stage of learning. In the early stages of acquisition, feedback about technique may be most beneficial after bad trials. Future studies might provide access to both KP and KR and track SC and YK participants' preferences and behaviors regarding the use of feedback. The results of such research should provide a clearer understanding of the relationship between feedback and learner preferences.

Explanations for Self-Control Effects

The present study represented an attempt to better understand self-control behavior during motor skill acquisition. In part, this effort aimed to address self-control in a manner that could provide greater insight into the mechanisms underlying the learning effects demonstrated in previous research. In past studies, researchers speculated that self-control might enhance motivation through increased confidence (Janelle et al., 1997), promote the use of more effective learning strategies (Chen, Hendrick, & Lidor, 2002), and allow participants to tailor a learning environment to their needs and preferences (Chiviacowsky & Wulf, 2002). Participant behaviors and responses to interview questions in the present study provided additional insights regarding these explanations.

Previous researchers have speculated that self-control might work to enhance performance through increased confidence. Participant preferences for feedback after primarily

good trials have been cited as evidence (Chiviacowsky & Wulf, 2002; Janelle et al., 1997). Other research has shown a connection between self-control and self-efficacy, such that the provision of self-control resulted in higher self-efficacy compared to a yoked control group (Bund & Wiemeyer, 2004). The current study examined potential changes in self-efficacy within a self-control protocol by assessing participants' self-efficacy at different levels of proficiency. For participants who achieved the highest levels of proficiency, self-efficacy patterns mirrored their performance and were consistent with the view that success plays an important role in self-efficacy levels (Bandura, 1997). For example, participants in the PR group reported increasing levels of self-efficacy throughout the study, with a peak at the final assessment. In contrast, participants in the EM group reported increasing levels of self-efficacy during practice but did not report continued increases prior to transfer. Self-efficacy for the participants in LL group remained relatively stable from the beginning of practice until the final assessment. These results suggest that self-confidence increases only when performance improves and the provision of self-control, per se, does not automatically confer a benefit to self-efficacy. Although all of the present participants had control over their practice environment, only those who achieved a certain level of proficiency were able to use KR to verify that progress. In post-training interviews, these participants described using KR to confirm success, increase confidence levels, and provide continued motivation to pursue more ambitious goals. This finding is consistent with self-determination theory, which contends that motivation is enhanced when individuals are allowed to control access to information that confirms their competence (Deci & Ryan, 2000), and with Bandura's (1977) thoughts on the connection between self-efficacy and motivation (Bandura, 1997). Such findings suggest that control may have provided benefits for self-efficacy in previous studies in two ways. Self-control may have initially allowed participants to access the

information necessary to improve skill. It may also have allowed participants the opportunity to access information that confirmed that improvement. The present results suggest that both increased access to information and confirmation of improvements are necessary for self-control to produce enhanced self-efficacy. Future researchers might address this issue more thoroughly by providing yoked participants with information that confirms progress. Such a design would help determine whether it is the opportunity to control or the information provided by that opportunity that impacts self-efficacy the most. The current findings suggest that control alone is not enough.

The current study also revealed some of the ways that self-control allows learners to tailor a situation to meet their individual needs or preferences (Chiviacowsky & Wulf, 2002). Because participants were given access to four types of assistance, they had the opportunity to tailor the instructional setting to a much greater extent than learners had in previous research. The present results indicated that participants used their requests to tailor the learning environment to their preferences, but not necessarily to their needs. For example, the graph depicted in Figure 7 shows request frequencies for 4 participants. Participant 102 utilized instruction, video demonstrations, and KP early in training prior to shifting to KR during the final 3 days of training. Participant 103 used KP throughout practice. Participants 112 and 126 asked for relatively little assistance throughout practice. As part of the post-training interview, participants were given the opportunity to describe how and why they chose to use each form of instructional assistance to discuss their use of goals and strategies. Participant 102 described setting his goals based on increases in the duration of juggling attempts. His request frequencies mirrored this preference and were dominated by KR during the later stages of practice. In contrast, participant 103 described a goal of perfecting his technique. His request frequencies

contained a much higher percentage of requests for KP. Participant 112 described a strategy based on repetition and the belief that physical practice was the key to skill acquisition. Her request frequencies were extremely low and after requesting each type of assistance only once on the first day, she requested no assistance at all on the second day. Finally, participant 126 described a preference for visual information over verbal information in her post-training interview. Rather than access instructions, she chose only to view the demonstration video. By providing participants with control over multiple types of assistance, the current study represents the first to produce evidence indicating that self-control allows learners to tailor a learning environment to match their goals and preferences.

Ironically, however, the results of this study also suggest that learner preferences may not always be in line with participants' needs. Several participants elected to forego assistance that might have helped them clarify the task. Several others seemed unaware of their need for assistance at times and, as a result, devoted considerable practice time to repetitions of improper technique. Figure 8 contains the request frequencies and performance curves for two participants who fit this description. Participant 117 did not access the instructions or demonstration until the second day of practice. By this point, she had developed an improper conception of the task and was never able to progress beyond two catches. Even after she requested assistance, she continued to make self-talk statements indicating a lack of understanding about the task (i.e., she expressed pleasure at making progress when there was no tangible evidence of improvement). Participant 114 described a preference for visual information during the post-training interview. This preference was consistent with his use of assistance. He accessed the demonstration but chose not to view the instructions. Additionally, he only asked for KP on one occasion. While he did improve during acquisition, his progress was not as dramatic as that of participants in the PR

group and seemed limited by his technique and failure to use assistance optimally. The instructions contained information about the benefits of making tosses to an ideal height. While this participant was cued to this information on the one occasion he did ask for KP, he appeared to choose not to adjust his technique. Perhaps if he had accessed the instructions earlier in training he would have been more receptive to the recommendations provided when he requested KP.

Other participants used assistance more effectively initially but later on seemed unaware of when assistance could be useful. For example, Participant 101 began performing a reverse-cascade juggle midway through practice. The reverse-cascade is more difficult and was not the technique taught in the instructions or illustrated in the demonstration. If she had asked for KP she would have been alerted to this mistake. Despite a decreasing rate of improvement, however, she chose not to access KP throughout the entire third day of practice and was not alerted to her mistake until the final day of practice. Although she gained enough proficiency to be in the PR group, her performance during retention and transfer was dramatically lower than the other participants in that group. Participant 110 behaved similarly. Despite a plateau in performance, he elected not to ask for assistance during his second day of practice and was not alerted to a flaw in his technique until the third day of practice. As a result, he devoted almost a third of his practice time to developing an incorrect technique.

In contrast, participants who became most proficient during the study demonstrated an understanding of both their preferences and their needs. The top two performers in retention each described strong preferences during their post-training interviews that corresponded to their request frequencies. Both participants also described a willingness to explore assistance that was

not in line with their preferences in their efforts to master the task. For example, participant 111 described a preference for visual information over instructions and a belief that a demonstration coupled with performance feedback should be enough to learn a skill. Despite this preference, he accessed the instructions when he was not able to correct a flaw early in practice. In his post-training interview, he commented that while demonstration was his preferred form of assistance for understanding a new motor task, the instructions provided valuable information that he would not have been accessed from the demonstration alone. Participant 126 also expressed a preference for demonstration over instructions. She did not request the instructions during practice but commented in the post-training interview that she would have done so had KP not provided the information she needed to progress.

The earliest self-control studies urged future researchers to explore the interplay of feedback with other self-regulatory skills to gain more insight into the possible mechanisms underlying self-control effects (Janelle et al., 1997). More recently, researchers have suggested the use of more complex tasks and the need to address the social-cognitive aspects of skill acquisition (Wulf & Lewthwaite, 2010a; Wulf & Shea, 2002). In response to these calls and consistent with research in self-regulation, the current investigator provided participants an opportunity to describe their use of strategies. These reports produced valuable information about how participants used the control they were given and also seemed to illustrate that the strategies learners use may have little to do with the provisions made by the researcher to facilitate self-control.

Self-regulation theories suggest that the most effective learning involves a systematic use of goal setting, performance, and evaluation to adapt to a learning situation (Cleary &

Zimmerman, 2000; Zimmerman, 2002). In the present study, the majority of participants either described or demonstrated behaviors indicating a systematic effort to evaluate and relate their behaviors and strategies to their respective goals. First, several participants described a process of evaluation that involved within-trial decisions about the quality of their technique. For example, participant 121 described only continuing an attempt if the first throw was ideal. Participant 118 described arbitrarily ending a trial whenever she felt that a throw was not high enough to allow the necessary time to make the next toss. Other participants behaved in ways that indicated within-trial evaluation. For example, participant 112 frequently ended attempts by reaching up and grabbing a juggling ball at its highest point. Participant 116 frequently caught the final ball in a 3- ball sequence without throwing the next ball, which would have begun another repetition of the sequence.

A second type of self-evaluation was seen in other participants who seemed to only evaluate their performance prior to and after each attempt. They were observed to engage in some form of rehearsal or self-talk prior to an attempt and then pause to reflect following an attempt. Participant 103 frequently repeated a key phrase from the instructions prior to an attempt and paused after each attempt, especially early in practice, in what seemed like an effort to self-evaluate. Participant 111 achieved the highest level of retention performance despite completing the fewest practice attempts. In part, the low attempt total reflected his increasing levels of proficiency throughout practice. Those totals also reflected his systematic reflection following attempts and his willingness to spend time prior to attempts in planning. Some participants were also more likely to juggle until failure rather than arbitrarily end a juggling attempt. For example, participant 102 went to extreme lengths to extend his juggling attempts. When poor throws were made (e.g., near the limit of his reach), he maintained his effort to regain

control over the juggling pattern and, by the end of practice, demonstrated an increased capability to successfully "rescue" attempts that went wrong. It is interesting to note that this participant went on to demonstrate the highest level of skill during transfer. The transfer task required participants to juggle balls of different weights, which produced many attempts that closely resembled those practice trials when participants lost control over the juggling pattern. It may be that his willingness to push himself to never concede failure during practice trials prepared him to meet the new demands imposed by the transfer task.

Participant behaviors were consistent with the notion of a three-phase process of self-regulation: (a) Forethought; (b) performance, and (c) self-reflection (Cleary & Zimmerman, 2001). Forethought involves both goal setting and strategy choice (Zimmerman, 2002). The performance phase involves self-monitoring but no self-evaluation, which emerges only in the self-reflection phase (Cleary & Zimmerman, 2001). According to this notion, while it is important for participants to be aware of what they are doing during performance, judgment should be withheld until after performance is completed. It seemed that for many participants described in the previous two paragraphs, self-evaluation occurred *during* performance, which may have hindered learning. In contrast, those who were able to simply monitor performance but wait until after an attempt to self-evaluate ultimately reached higher levels of proficiency. In terms of performance, perhaps devoting attention to in-the-moment evaluation limited the attention that could be devoted to the movement demands of the task. Given the inherent limitations of information processing capacity (Schmidt & Wrisberg, 2008), participants who attempted to both evaluate and monitor may have been overwhelmed by their attempts to process too much information at one time. Those who were able to monitor during performance while refraining from evaluation may have been able to better manage in-the-moment task demands.

Self-regulation theories suggest that it is important to engage in the right processes at the right time. While many participants in the EM group did appear to engage in the right processes, those in the PR group demonstrated an ability to engage in those processes in a manner more consistent with their ability to manage that information.

Participant behaviors regarding evaluation seemed tied to the strategies they reported. Table 13 lists strategies for each participant by performance group. Participants reported strategies tied to controlling practice structure, directing their focus of attention, or using the instructional assistance to develop proper technique. Some of these strategies either explicitly involved within-trial evaluation or seemed to promote it. The key determinant in whether a strategy promoted proper evaluation seemed to be whether the strategy directed a participant's focus toward or away from the specific movements involved in juggling. For example, participants 110, 112, and 123 stated that they tried to direct and control their movements. Participant 123 even described her strategy as "the hand technique" and reported directing her attention toward releasing each ball properly. Other participants described strategies related to practice structure that seemed more likely to direct attention to the control of individual movement. Participants 120 and 121 described their strategies in terms of segmentation. Each spoke of building their juggling technique piece by piece and only moving on to the next piece when they felt the prior piece was satisfactorily performed. While such statements do not suggest an overt attempt to control movements, they may have promoted a focus on individual movements. In contrast, other participants described strategies that directed attention away from the individual movements involved in the cascade juggle. For example, participants 114 and 111 both reported focusing on the feel or rhythm of the overall pattern of movement. Participants 102, 111, 124, and 126 all reported either tracking the colors of the thrown balls and/or counting

tosses. Other participants described simply attempting to mirror the instructions for juggling, which directed their focus to the area in front of their forehead where the juggling balls should reach peak height. Previous studies in motor learning have suggested the benefits of adopting an external focus of attention, which can be described as a focus directed outwardly toward objects or the environment (Wulf, 2007a). In the current study, there seemed to be less of a distinction between internal focus, which can be described as directing attention toward thoughts, feelings, or control of movements, and external focus (Wulf, 2007a). Instead, participants who found a way to focus on something outside of their individual movements, whether through an internal or external focus of attention, performed more effectively than those whose attention seemed tied to controlling specific movements. The key contributor to success seemed to be finding a focus that prevented participants from being overwhelmed by too much thinking. Similar to the role of evaluation, participants who found a way to limit the cognitive demands of performance by simplifying their focus were more effective in acquiring the cascade juggle than those who attempted to devote attention to controlling and evaluating individual movements.

Conclusions

The primary purpose of the present study was to gain a better understanding of self-control behavior. Participants were afforded levels of control not previously seen in self-control research. Their behaviors, their responses to interview questions, and their performance provided greater insight into self-control behaviors and the mechanisms underlying self-control effects. Rather than fading requests for all assistance, patterns were tied to the type of assistance and the role that the assistance played. Regardless of proficiency level, participants showed a tendency to decrease requests for informational forms of assistance over the course of acquisition. Requests for KR, however, increased with increasing levels of proficiency throughout practice. This

finding is unique in the self-control literature and suggests a more complex relationship between feedback requests and dependency than has been previously demonstrated. In addition, participants reported using KR to monitor their progress and enhance their confidence and motivation. This is consistent with the speculation that self-control effects may, in part, be due to motivational factors. Control over multiple forms of assistance also allowed participants to tailor the practice setting to their preferences in very distinct ways. Participant interview responses indicated strong preferences for certain types of instructional assistance and their patterns of requests seemed to confirm such tendencies. These findings offer support for the idea that self-control allows individuals to tailor a learning environment to their preferences while demonstrating that such tailoring in and of itself is not always effective. For many participants, preferences did not necessarily align with needs or optimal choices. The current findings suggests that self-control offers the freedom to tailor an environment but that participants may only benefit when that freedom is accompanied by a proper knowledge of how to structure the learning experience.

Perhaps the most important contribution of the present study to the research on self-control is the insights the results provided into the *learning experience* of participants. It appears that the learning process unfolds in a much richer manner than can be understood by relying solely on tightly controlled quantitative approaches. While the study provided evidence that supported previous speculations advanced in the self-control literature, it also revealed that participants behave much differently than expected in some instances. For example, the frequency of requests for assistance was far below what was expected and participants utilized assistance in ways that were not anticipated. These behaviors highlight the potential weaknesses of specifying experimental conditions that may or may not meet with learner needs. Results also

demonstrate that participants may choose to control factors outside of the study protocol. In the current research, participants were given far greater control than in previous studies. Despite that, some of the most important decisions participants made seemed to involve factors outside the bounds of the instructional assistance offered. Participant choices about pacing and focus of attention seemed to influence learning much more than the frequency with which participants accessed instructional assistance. The protocol allowed participants to choose *when* they would access information. It seems clear that the most influential aspects of control, however, related to *how* participants chose to use that information. Participant responses to interview questions and participant behaviors revealed that decisions about how to engage in evaluation and where to direct attention impact performance the most. These were not aspects that were controlled by the protocol and were not results that were anticipated. These findings suggest that individuals will use whatever latitude they can find within *any* protocol and use it in ways that they *think* will help. In addition to monitoring behaviors and performance, it may be important to monitor participant thoughts and feelings about the learning experience to gain an even more accurate picture of the mechanisms underlying learning and the logic behind participant decisions. At the very least, the current study suggests that alternative methods of investigating motor learning are viable for gaining greater clarification of previous findings as well as generating direction for future efforts. Motor learning research may be served by offering other forms of control for participants while collecting greater amounts of information about participant thoughts and feelings during the learning process.

Key Findings Related to Self-Control Research

1. Regardless of proficiency level, participants demonstrated a tendency to decrease requests for instructions, demonstration, and KP throughout acquisition.
2. Requests for KR increased throughout acquisition for those who became increasingly proficient.
3. Participants reported requesting KR after primarily good attempts.
4. Participants reported utilizing KR to monitor progress and increase confidence.
5. Participants reported requesting KP after both good and bad attempts.
6. Participants reported utilizing KP to identify mistakes and monitor their progress in correcting those mistakes.

Practical Applications

The findings of this study have several practical applications. While learning the cascade juggle, participants were afforded a level of control not previously granted in motor learning studies. For this reason, the learning environment more closely mirrored realistic settings and the findings offer potentially useful insights about learners for coaches and teachers. Although the purpose of the study related to specific issues within motor skill acquisition, the practical applications address more general ideas about learning and aspects that need to be considered when assisting individuals.

While learning to juggle, participants were given access to a wealth of information. In addition, they were presented with many potential directions in which to focus their attention while performing the experimental task. This level of freedom could potentially introduce an

attentional issue in practical settings. It is well established that, in times of stress, attentional narrowing may occur and performers may incorrectly direct their attention (Weinberg & Gould, 2007). In many practical performance and learning settings, stress very well may be a factor. Practitioners need to weigh the benefits of increased freedom against the potential for attentional narrowing and impaired performance or develop strategies to help performers maintain appropriate attentional focus.

The results from the study also reinforced the idea that individuals enter learning situations with expectations and previous experiences that potentially influence the outcome of training. Participants' previous experiences with motor skills seemed to influence their expectations about success with the experimental task. Some participants expressed a confidence in their ability to learn the task. Others related previous difficulties with learning motor skills. All were given control and time to practice. Self-efficacy, however, differed greatly among participants and was highly related to proficiency. This is consistent with Bandura's (1997) ideas about the reinforcing cycle of successful performance and self-efficacy. Previous success is the most important contributor to self-efficacy levels, and participants arrived with various levels of previous success in movement-related skills. Although the provision of self-control to learners is consistent with ideas about how to foster self-efficacy, the current results suggest that this provision did not completely mitigate some differences that might have been due to initial levels of proficiency and self-efficacy. Thus, practitioners should remember that individuals enter even the most supportive learning situation with a unique history that should inform the tailoring of instruction to individual needs.

The results from this study also suggest that individuals with different proficiency levels have different instructional needs. This evidence is consistent with Schmidt and Wrisberg's (2008) advice about assisting learners as they progress through stages of learning. For example, in the verbal-cognitive stage of learning, individuals are simply trying to understand what to do. As a practitioner, it may be best to provide visual models or demonstrations. It also may be helpful to simplify the skill in some way to reduce the attentional demands. As individuals progress to the motor stage, where they are seeking to refine the skill, practitioners should adjust practice conditions to more closely mirror the demands of the target context. Several participants in the current study expressed a desire to engage in part-practice while learning. It seems that they were attempting to modify the skill to reduce the attentional demands and adjust to their own stage of learning. While participants were provided with visual models, they were not given the option of part-practice. One goal of the study was to provide participants with a level of control that had not previously been granted. In some cases, however, it appears that the freedom did not extend to the aspects of practice that would have been helpful to every participant. It may be best for practitioners to identify an individual's level of proficiency prior to deciding what type of practice to implement and what aspects of practice a learner will control. Another option in practical settings not restricted by the need for experimental control would be to adopt a collaborative approach with the learner in which additional modes of instructional support can be added as a potential need for them is identified.

All of the foregoing thoughts about practical application emphasize the idea that individual differences play an important role in learning. Motor learning research has traditionally explored learning with an experimental approach. Such an approach has been invaluable for arming practitioners with evidence-based approaches to instruction. The findings

of the current study highlight the importance of trying to accommodate individual differences within the frameworks provided by the experimental research on various factors known to influence performance and learning. An important part of knowing what evidence-based approach to adopt will emerge from an understanding that preferences and previous experiences of the learner will influence their success. Practitioners ideally enter a learning situation with advanced knowledge of both instruction and the task at hand. Learners possess advanced knowledge of their own experiences, preferences, and expectations. The best learning may occur when both parties contribute their expertise.

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APPENDICES

Appendix A

Informed Consent Statement

An experiment to examine learning a complex skill

You are invited to participate in a research study. The purpose of this study is to investigate how individuals use information when learning a new motor skill. For this study, you will be learning a 3-ball cascade juggling skill. During the study, you will participate in up to 9 separate practice sessions and 1 testing session held over a 2-week period. The sessions will last between 45-60 minutes each. During the final session, you will be tested to see how well you have learned to juggle. Data from your performance will be video recorded and stored on a computer for later analysis.

At different times during the study, you will complete short surveys regarding your confidence level. At the end of your practice sessions, you will also be asked several questions about your experience of learning to juggle. Your answers will be audio recorded and interview will take approximately 10 minutes. As soon as the recordings are transcribed to text, however, they will be erased. During the final session, you will complete two tests to assess your learning and you will complete another survey about your confidence level. Throughout the study, your performance will be videotaped. The video will only be used to collect data about your juggling performance. Once data is recorded, the video will be destroyed. At the end of the final session, you will have the opportunity to learn about the research project if you so desire.

If you volunteered for this experiment through the Human Participation in Research (HPR) Website in exchange for course credit, your participation will be reported to that website. The experimenters conducting this study are not directly involved in awarding course credit. They simply report whether or not you participated in the study.

The information in the study records will be kept confidential. Data will be stored securely and will be made available only to persons conducting the study unless you specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link you to the study.

This study poses minimal risk to participants. If physical injury is suffered in the course of research, the University of Tennessee does not "automatically" reimburse subjects for medical claims or other compensation. For more information or for answers to other questions about the study, you may contact Dave Laughlin via the telephone number or email indicated below or his faculty supervisor, Dr. Jeff Fairbrother (865-974-3616; jfairbr1@utk.edu). If you have any questions about your rights as a participant, contact the Research Compliance Services section of the Office of Research at (865) 974-3466.

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed, your data will be returned or destroyed.

I have read the above information and agree to participate in this study. I have received a copy of this form.

Participant's name (please print): _____

Participant's signature: _____ Date: ___/___/_____

Investigator's signature: _____ Date: ___/___/_____

David D. Laughlin
Department of Kinesiology, Recreation, and Sport Studies
dlaughl2@utk.edu
(865) 974-8138

Appendix B

Self-Efficacy Inventory*

Instructions: To be read by experimenter prior to each administration

Post-introduction instructions

Think about the 3-ball juggling skill you have just attempted. How confident are you that you can successfully juggle:

Point of proficiency instructions

Think about the 3-ball juggling skill you have been practicing. How confident are you that you can successfully juggle:

Pre-transfer assessment

Think about the new juggling skill you have just been shown. How confident are you that you can successfully juggle:

Participant Directions: Please circle **one** number for each question.

	I'm certain I *can't* do this			I'm *moderately* certain I can do this					I'm very certain I *can* do this	
1. For at least 5 seconds?	0	1	2	3	4	5	6	7	8	9	10
2. For at least 10 seconds?	0	1	2	3	4	5	6	7	8	9	10
3. For at least 15 seconds?	0	1	2	3	4	5	6	7	8	9	10
4. For at least 20 seconds?	0	1	2	3	4	5	6	7	8	9	10
5. For at least 25 seconds?	0	1	2	3	4	5	6	7	8	9	10
6. For at least 30 seconds?	0	1	2	3	4	5	6	7	8	9	10
7. For at least 35 seconds?	0	1	2	3	4	5	6	7	8	9	10
8. For at least 40 seconds?	0	1	2	3	4	5	6	7	8	9	10
9. For at least 50 seconds?	0	1	2	3	4	5	6	7	8	9	10
10. For at least 60 seconds?	0	1	2	3	4	5	6	7	8	9	10

*Adapted from Garza & Feltz, 1998

Appendix C

Post-Training Interview Guide

Instruction

1. How often did you ask for instructional cues **<u>to provide guidance for the upcoming attempt</u>**?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

2. How often did you ask for instructional cues **<u>to provide correction for the previous attempt</u>**?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

3. Follow-up: Did you have other reasons for asking for instructional cues? If so, please explain.

Video Demonstration

1. How often did you ask for video demonstrations **<u>to provide instruction for the upcoming attempt</u>**?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

2. How often did you ask for video demonstration **<u>to provide correction for the previous attempt</u>**?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

3. Follow-up: Did you have other reasons for asking to view the demonstration? If so, please explain.

KP

1. How often did you ask for feedback about your technique when you thought your juggling was relatively ***good***?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

2. Follow-up: Did you have a specific reason for this choice? If so, please explain.

3. How often did you ask for feedback about your technique when you thought your juggling was relatively ***bad***?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

4. Follow-up: Did you have a specific reason for this choice? If so, please explain.

KR

1. How often did you ask for feedback about your time when you thought your juggling was relatively ***good***?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

2. Follow-up: Did you have a specific reason for this choice? If so, please explain.

3. How often did you ask for feedback about your time when thought your juggling was relatively ***bad***?

1	2	3	4	5
Never	Seldom	Occasionally	Often	Always

4. Follow-up: Did you have a specific reason for this choice? If so, please explain.

Strategies & Goals

1. Did you use and/or develop any particular strategies while learning to juggle? If so, what kind of strategies did you use? Did those strategies change as you practiced?

2. Did you set any particular goals while learning to juggle? If so, what were those goals? Did they change as you continued to practice?

Additional Questions

1. At what point during practice did you feel like you had reached proficiency?

2. What do you think about the quality of the instructional assistance that was available to you while you learned?

3. Is there anything else that I have forgotten to ask that you think is important?

Appendix D

Data related to performance, requests for instructional assistance, self-efficacy, and post-training interview responses

Day 1 juggling performance, self efficacy assessments (#), and requests for instruction, video demonstration, KP, and KR

ID	101	102	103	107	109	110	111	112	113	114	115	116	117	118	120	121	122	123	124	126
Age	18	19	22	18	20	18	19	19	18	19	18	19	18	18	19	20	18	18	18	20
Gender	F	M	M	M	F	M	M	F	F	M	M	M	F	F	F	F	F	F	M	F
Hand	R	R	R	R	R	R	L	R	R	R	L	R	L	R	R	L	R	R	R	R
Group	PR	PR	PR	EM	EM	EM	PR	EM	LL	EM	EM	EM	LL	EM	LL	LL	LL	LL	PR	PR
1	1	2	3	1	3	2	3	1	1	3	1	1	1	0	0	1	0	1	3	2
2	1	1	2	1	2	2	2	1	1	2	2	1	1	1	1	1	0	0	3	2
3	2	1	4	2	3	2	4	2	1	2	1	2	1	1	2	2	1	1	3	3
4	1	2	2	1	1	2	6	2	2	2	2	2	0	2	2	1	0	0	3	3
5	2	2	1	1	2	1	2	2	2	3	2	2	1	2	1	1	1	1	2	5
6	1	1	2	2	2	2	4	3	2	2	2	2	1	1	1	1	0	1	3	4
7	1	1	2	1	3	0	1	3	1	3	2	2	1	2	1	1	0	0	2	4
8	1	2	3	1	3	0	5	2	2	3	2	1	1	1	1	1	1	1	2	3
9	2	2	3	0	1	1	4	3	2	3	1	2	1	1	0	1	1	1	3	4
10	1	1	4	1	1	1	2	4	2	2	2	2	1	1	0	1	1	1	3	3
11	1	1	4	1	2	1	4	2	2	4	1	2	0	1	1	0	0	1	2	1
12	1	2	2	0	2	0	2	1	2	2	1	0	1	2	1	1	1	1	2	0
13	2	1	1	0	2	1	3	2	2	1	2	0	1	2	1	1	1	1	4	0
14	1	1	2	0	2	1	4	3	2	2	1	2	1	2	1	1	1	1	4	3
15	2	2	3	1	1	0	1	2	2	2	2	2	1	1	1	1	1	1	3	3
16	0	2	3	2	3	0	6	2	1	2	1	0	0	2	1	1	1	1	4	5
17	2	1	3	2	2	1	3	2	2	2	0	1	1	2	1	0	0	1	2	3
18	1	1	2	1	2	1	6	2	2	2	1	2	1	1	1	1	1	1	5	3
19	2	1	5	2	1	0	2	2	2	4	2	3	1	2	1	1	0	2	3	2
20	2	2	3	1	2	1	7	3	2	3	1	0	1	1	1	1	0	1	4	2
21	2	1	4	1	2	0	3	2	1	3	2	1	1	2	1	1	1	1	2	3
22	1	2	2	0	2	1	3	2	1	4	1	0	0	0	1	1	1	1	3	3
23	2	2	5	1	2	1	3	2	0	3	1	2	1	2	1	1	0	1	3	2
24	2	2	2	1	3	1	4	1	1	4	2	0	1	0	1	1	1	1	4	1
25	3	1	3	1	2	1	6	3	2	1	2	2	2	2	1	1	0	1	3	3
26	3	2	3	2	2	0	4	2	2	2	2	0	2	2	1	0	0	2	4	3
27	3	0	3	1	2	1	4	2	2	3	2	0	1	2	1	0	1	0	5	3
28	3	2	4	1	3	1	4	1	1	3	1	2	2	2	1	1	1	1	3	3
29	3	0	4	2	0	0	6	1	2	2	1	1	1	3	1	2	0	1	2	4
30	3	0	1	3	0	0	5	1	2	1	3	1	1	2	1	1	1	1	3	10

31	2	1	2	2	0	1	7	2	2	2	2	1	1	2	1	1	1	1	3	3
32	3	2	2	3	3	2	2	2	2	3	3	1	1	1	1	1	1	2	1	5
33	3	0	1	2	1	0	3	1	2	2	2	2	1	2	2	2	0	1	3	4
34	3	2	3	1	0	1	3	2	1	3	2	2	1	2	1	0	1	2	3	4
35	3	3	3	0	0	0	6	2	2	2	2	2	1	2	2	0	1	1	3	11
36	3	3	4	1	2	1	2	2	1	2	2	1	2	1	2	1	0	2	4	0
37	3	1	4	1	3	0	8	0	2	4	1	0	1	1	1	0	0	1	4	3
38	2	3	2	2	2	0	6	2	2	4	3	1	1	0	2	0	0	2	4	5
39	2	2	2	2	2	0	7	2	2	2	3	2	1	1	1	0	1	1	3	9
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41	2	1	2	2	1	1	4	2	1	3	0	1	1	1	2	1	1	1	3	11
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45	3	1	3	1	1	0	1	1	2	2	2	2	1	2	0	1	0	0	3	1
46	3	2	4	1	3	0	1	2	2	2	3	1	0	2	1	2	0	0	2	3
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48	2	3	1	2	0	1	3	2	1	2	1	1	2	2	1	0	1	1	3	5
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52	3	3	1	1	1	1	6	2	2	4	0	1	1	2	1	1	0	0	4	2
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55	3	0	3	1	1	1	2	2	2	2	3	1	1	2	1	1	0	1	3	3
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60	1	3	3	2	5	2	2	2	2	3	2	0	1	2	1	0	1	1	3	7
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86	1	3	3	2	4	2		2	2	5	4	2		3	1	2	1	1	3	6
87	2	3	5	1	2	6		2	2	3	2	2		2	1	2	0	0	1	3
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95	2	4	2	2	4	3		2	2	3	2	2		1	1	2	1	1	3	6
96	3	2	5	3	5	2		2	2	5	3	5			1	2	1	0	1	22
97	0	3	4	0	1	2		2	1	4	2	1			1	1	0	0	3	12
98	2	2	4	0	2	2		2	1	3	2	2			0	2	0	0	3	0
99	2	3	4		5	1		2	2	3	4	1			1	1	0	2	2	16
100	4	3	4		2	3		2	2	6	2	2			1	1	0	1	3	15
101	3	3	4		4	0		2	2	4	1	1			1	1	1	1	3	0
102	4	10			3	1		2	2	2	2	2			1	2	1	2	3	8
103	4	2			3	1		1	2	1	2	2			0	1	1	0	3	6
104	2	5			3	4		2	2	0	4	2			2	1	1	2	3	6
105	1	3			3	4		2	2	2	2	0			1	0	1	1	2	6
106	2	2			2	1		3	2	2	2	1			1	0	1	1	3	2
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115	2	1			2	4		3	1	5	0	2			2	2	1		3	4
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117	4	3			4	5		2	2	4	2	2			0	1	0		3	2
118	4				4	6		2	0	4	3	4			1	2	1		2	6

119	4	2	3	4	0	3	1	0	2	0	1	3	7
120	2	3	3	4	2	3	2	0	2	1	0	1	9
121	5	4	0	2	2	4	3		1	2	1	3	8
122	6	2	3	2	2	4	3		2	1	0	1	3
123	2	4	4	2	2	3	1		0	2	0	1	11
124	10	2	3	2	1	3	3		1	1	1	1	7
125	2	3	1	1	2	3	3		2	2	1	2	3
126	4	3	3	4	1	3	2		1	1	1	1	9
127	0	4	5	4	2	4	1		1	0	0	3	8
128	2	5	0	6	1	6	3		0	0	0	1	6
129		0	4	2	2	7	1		0	2	0	2	17
130		3	3	1	2	5	2		0	1	0	0	5
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230	2	0			2	1	3
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253	4	1	1	2	1
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255	1	2	0	2	1
256	4	1	0	2	0
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346		1

Day 2 juggling performance and requests for assistance

ID	101	102	103	107	109	110	111	112	113	114	115	116	117	118	120	121	122	123	124	126
Age	18	19	22	18	20	18	19	19	18	19	18	19	18	18	19	20	18	18	18	20
Gender	F	M	M	M	F	M	M	F	F	M	M	M	F	F	F	F	F	F	M	F
Hand	R	R	R	R	R	R	L	R	R	R	L	R	L	R	R	L	R	R	R	R
Group	PR	PR	PR	EM	EM	EM	PR	EM	LL	EM	EM	EM	LL	EM	LL	LL	LL	LL	PR	PR
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4	2	4	5	1	1	3	14	2	2	6	2	2	1	1	2	2	1	2	3	34
5	3	6	5	1	2	3	24	3	2	5	1	2	2	3	1	0	1	2	1	10
6	3	6	2	3	3	5	6	6	2	10	3	3	1	2	2	1	0	0	2	40
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8	6	2	3	3	2	3	8	2	1	10	4	1	1	2	2	1	1	2	1	41
9	3	3	4	2	2	4	4	2	2	5	2	1	2	2	2	2	1	2	0	28
10	4	9	4	1	3	4	11	3	2	3	4	3	2	2	0	2	1	2	2	40
11	3	5	3	3	0	7	6	3	2	3	0	1	2	2	1	1	0	2	2	28
12	4	7	4	2	0	7	10	0	2	6	2	2	2	2	2	1	0	2	0	21
13	5	8	4	2	3	5	26	4	3	4	2	3	1	1	2	2	1	1	2	15
14	0	3	5	2	2	3	6	4	2	5	3	1	2	2	2	1	1	1	3	32
15	4	4	5	3	3	3	3	4	3	17	1	2	2	3	1	2	0	1	0	11
16	4	12	5	3	3	2	24	3	2	6	1	3	2	3	1	1	1	2	1	54
17	6	5	4	0	4	5	35	3	2	9	2	3	1	2	1	1	1	2	3	10
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22	0	4	5	1	1	6	8	2	2	4	3	3	2	1	1	2	0	1	2	9
23	6	5	4	1	2	4	14	2	1	4	1	1	1	2	2	0	1	2	0	47
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25	3	5	2	3	2	5	8	2	1	9	1	2	2	1	0	2	1	1	2	23
26	8	5	3	1	3	2	21	2	1	7	2	3	1	2	2	2	0	2	3	5

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185				3	4	2	3	1	2	0	2	1	2	3
186				10	4	0	2	3	1	1	1	0	3	0
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188				9	2	2	2	2	2	2	0	0	2	5
189				7	3	3	4	2	2	1	0	0	3	4
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192				8	2	2	1	3	2	1	2	1		5
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194				8	3	3	1	3	2	2	2	1		2
195				7	3	3	2	2	2	1	2	1		0
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198				4	2	2	2	1	1	1	0	0		4
199				12	2	2	5	3	2	1	1	1		4
200				14	4	0	4	1	2	2	0	1		0
201				4	2	3	3	1	1	2	2	1		4
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269			4	4	3	0	2	1	2
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316	2	4	1	2		2	1
317	2	6	2	2		2	5
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413			2	
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495	1

Day 3 juggling performance and requests for assistance

ID	101	102	103	107	109	110	111	112	113	114	115	116	117	118	120	121	122	123	124	126
Age	18	19	22	18	20	18	19	19	18	19	18	19	18	18	19	20	18	18	18	20
Gender	F	M	M	M	F	M	M	F	F	M	M	M	F	F	F	F	F	F	M	F
Hand	R	R	R	R	R	R	L	R	R	R	L	R	L	R	R	L	R	R	R	R
Group	PR	PR	PR	EM	EM	EM	PR	EM	LL	EM	EM	EM	LL	EM	LL	LL	LL	LL	PR	PR
1	2	13	4	3	3	4	4	2	1	16	2	3	0	2	0	2	1	2	4	142
2	5	64	9	3	5	2	4	4	2	2	2	2	1	3	1	2	1	2	6	39
3	3	31	20	3	2	2	16	3	1	7	3	3	1	2	2	1	0	3	3	95
4	14	8	5	4	2	3	19	6	3	6	3	2	1	3	1	2	1	0	4	84
5	7	27	2	2	4	6	13	4	1	9	4	2	1	2	1	2	1	0	4	92
6	11	17	5	1	1	5	5	10	3	6	4	2	1	1	1	2	0	1	3	109
7	3	53	2	3	6	7	30	2	3	9	4	3	0	2	1	2	1	3	2	108
8	5	77	6	1	3	5	12	3	2	5	2	1	0	3	1	2	1	1	3	20
9	9	8	23	3	3	5	22	6	2	6	7	1	1	2	1	2	1	1	3	91
10	5	38	21	2	3	2	45	2	3	4	5	4	2	3	1	2	1	2	3	5
11	8	30	9	2	3	7	8	4	2	6	3	3	0	4	2	2	1	1	3	8
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13	10	28	3	3	3	3	7	3	2	3	4	5	0	4	1	2	0	3	1	25
14	6	25	23	2	2	8	21	8	3	13	2	3	2	4	0	2	1	2	0	113
15	12	22	3	2	2	1	41	4	4	8	2	3	1	4	2	2	0	2	2	62
16	5	14	8	3	7	5	8	5	4	1	9	4	1	2	1	2	0	2	6	91
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19	3	32	26	2	4	1	20	8	1	5	2	3	0	1	2	2	0	3	3	1
20	4	29	18	2	2	3	16	4	3	1	7	3	1	0	1	2	0	2	0	51
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265	5	2	4	2	0	3	2
266	4	4	5	4	1	3	11
267	2	6	5	3	0	3	3
268	6	7	16	2	2	4	3
269	4	2	3	3	0	3	1
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272	2	2		1	0	1	3
273	2	2		5	1	3	0
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276	6	2		7	1	4	3
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283		6		4	0	3	14
284		4		2	2	2	11
285		2		5	0	2	12
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299		0		5	1	2	1
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321		2	4	0	3	9
322		2	6	1	4	7
323		2	2	0	3	14
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327		2	6	0	3	7
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475		3
476		2
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497	2
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499	4
500	4
501	4

Day 4 juggling performance and requests for assistance

ID	101	102	103	107	109	110	111	112	113	114	115	116	117	118	120	121	122	123	124	126
Age	18	19	22	18	20	18	19	19	18	19	18	19	18	18	19	20	18	18	18	20
Gender	F	M	M	M	F	M	M	F	F	M	M	M	F	F	F	F	F	F	M	F
Hand	R	R	R	R	R	R	L	R	R	R	L	R	L	R	R	L	R	R	R	R
Group	PR	PR	PR	EM	EM	EM	PR	EM	LL	EM	EM	EM	LL	EM	LL	LL	LL	LL	PR	PR
1	3	5	3	6	1	1	22	3	0	6	3	2	1	0	0	1	1	2	3	52
2	14	89	4	6	3	2	89	2	3	7	4	4	0	0	1	1	0	2	10	199
3	13	179	44	3	6	2	74	4	3	8	10	1	1	5	2	2	0	1	9	43
4	4	99	67	5	3	3	29	5	3	30	1	4	1	4	0	2	1	2	12	15
5	2	108	51	16	1	4	35	2	4	3	3	3	0	4	0	2	1	1	2	10
6	16	118	14	2	2	9	85	2	3	12	4	1	1	2	1	2	1	2	20	22
7	3	8	4	9	2	2	72	2	2	9	10	2	1	1	2	3	0	2	4	63
8	1	104	2	3	3	5	51	2	3	25	10	1	1	4	2	4	1	1	6	489
9	3	42	63	13	4	3	52	2	2	28	4	4	0	0	2	4	0	3	35	
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11	7	24	19	5	2	1	36	2	2	9	5	5	2	0	1	3	1	3	13	
12	4	2	9	6	4	2	107	2	2	4	14	5	1	0	1	0	0	3	5	
13	5	66	5	2	6	3	102	2	4	41	4	5	1	5	2	0	1	3	27	
14	12	40	50	3	2	8	82	2	2	31	2	7	1	6	2	0	0	1	11	
15	7	37	36	10	0	2	31	4	1	5	0	6	1	1	0	0	1	3	10	
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19	14	230	31	12	2	3	31	2	2	4	4	2	0	5	0	2	1	4	19	
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23	5	184	4	9	3	5	71	5	2	7	9	0	1	1	2	1	1	2	16	
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27	6		17	2	3	3		13	4	3	9	1	1	6	0	0	1	1	12	
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137	10	2	4	13	3	2	5	3	3	2	0	4	0	2	15
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149	15		2	7	4	3		5	4	1	0	1	1	3	9
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152	10		6	9	2	4		6	4	2	0	1	1	3	7
153	7		6	1	2	2		6	5	1	0	2	0	1	9
154	15		0	9	2	0		8	10	3	1	2	0	2	11
155	6		5		0	3		2	2	1	0	4	1	0	0
156	5		3		0	3		7	6	4	0	2	0	2	31
157	10		6		2	2		2	2	2	0	3	1	3	23
158			4		3	1		3	5	2	3	5	1	3	8
159			2		4	3		9	1	2	3	0	0	0	13
160			4		4	0		4	2	3	0	3	0	4	
161			3		3	2		2	6	1	2	2	1	3	
162			2		3	2		2	3	1	0	0	1	3	
163			4		4	3		4	2	1	2	4	0	0	
164			2		6	2		3	11	2	2	3	1	3	
165			6		6	4		8	3	4	0	1	0	2	
166			2		8	3		6	3	3	0	2	1	2	
167			4		2	3		0	2	6	1	0	1	3	
168			4		2	3		13	3	4	0	2	1	0	
169			4		2	3		2	9	7	2	2	1	0	

170	2	2	2	3	4	4	2	0	1	2
171	6	4	1	5	2	3	2	3	0	3
172	4	8	3	13	5	3	2	2	1	3
173	7	0	1	1	6	6	1	5	1	3
174	7	4	2	1	6	7	2	3	1	0
175	4	9	2	14	2	2	2	2	0	1
176	6	4	2	8	4	2	0	2	1	2
177	0	5	1	2	3	4	2	0	1	0
178	8	0	2	1	6	2	2	4	1	2
179	6	2	2	10	5	4	2	1	0	3
180	6	8	3	1	2	2	2	3	1	3
181	5	7		2	2	2	1	3	0	0
182	6	2		8	7	4	1	3	1	3
183	1	4		6	3	4	3	5	1	0
184	0	2		3	4	2	3	2	1	3
185	0	2		4	2	2	1	1	1	3
186	12	6		19	9	6	0	2	1	3
187	2	2		8	6	2	2	0	1	4
188	2	1		1	3	1	0	0	1	0
189	9	2		4	3	1	1	3	0	2
190	4	2		11	2	4	0	0	1	1
191	2	0		8	0	3	1	2	0	3
192	6	2		6	7	2	0	6	1	3
193	8	2		6	0	1	0	3	1	3
194	3	6		1	1	2	3	0	1	3
195	6	2		6	4	0	2	0	1	3
196	3	10		3	2	3	0	0	1	1
197	2	0		4	10	6	3	3	0	2
198	8	4		0	2	3	1	0	1	2
199	5	5		7	2	3	0	3	1	2
200	14	4		22	2	4	2	4	1	3
201	6	4		5	16	4	0	5	1	3
202	2	4		4	7		0	3	0	4
203	2	4		2	7		0	2	1	4
204		4		8	4		2	2	1	2
205		7		2	3		0	0	0	2
206		7		14	4		3	2	1	2
207		4		8	2		0	4	1	2
208		9		12	4		0	6	1	1
209		3		9	9		2	3	0	2
210		4		17	5		0	4	0	2
211		2		19	11		0	2	0	2
212		2		11	4		0	3	0	2
213		3		5	6		0	0	1	2

214	6	10	4	2	3	1
215	7	5	3	0	0	1
216	4	18	2	2	2	1
217	4	14	3	0	0	0
218	5	20	4	0	2	1
219	7	10	12	3	0	1
220	4	10	7	0	3	1
221	4	5	1	2	2	1
222	6	10	4	0	3	1
223	3	9	6	2	3	1
224	10	11	3	0		1
225	2	7	4	2		1
226	6	2	7	0		1
227	2	13	5	0		1
228	2	5	5	1		1
229	4	2	1	0		1
230	2	17	3	0		1
231	2	11	8	2		1
232	2	18	2	0		0
233	5	11	3	0		1
234	5		21	0		1
235	2		11	0		1
236	4		10	3		1
237	2		7	0		0
238	3		6	0		1
239	2		4	3		1
240	2		5	0		1
241	3		4	1		0
242	2		6	0		1
243	4		5	0		1
244	2		7	2		0
245	7		4	0		1
246	4		3	3		0
247	5		3	0		
248	1		4	2		
249	6		2	0		
250	5		13	0		
251	3		9	3		
252	2		17	0		
253	4		3	0		
254	5		5	0		
255	2		2	0		
256	2		4	0		
257	2		1	2		

258	2	3	0
259	2	2	1
260	5	8	0
261	4	7	0
262	5	17	0
263	2	7	0
264	6	4	0
265	0		0
266	0		0
267	4		0
268	6		2
269	2		0
270	2		0
271	8		0
272	2		0
273	7		3
274	2		0
275	2		2
276	4		0
277	5		0
278	7		4
279	5		0
280	2		0
281	2		3
282	2		0
283	7		0
284	4		0
285	5		3
286	4		0
287	2		2
288	0		0
289	2		0
290	2		3
291	2		0
292	6		3
293	6		0
294	4		0
295	2		2
296	2		0
297	2		0
298	2		2
299	6		0
300	4		0
301	2		2

302	5	0
303	1	0
304	2	4
305	2	0
306	7	0
307	5	0
308	3	4
309	2	0
310	5	0
311	2	0
312	5	0
313	4	0
314	8	0
315	4	0
316	3	0
317	0	0
318	4	0
319	4	0
320	4	0
321	6	0
322	3	0
323	9	0
324	5	2
325	4	0
326	6	3
327	8	0
328	14	0
329		0
330		0
331		2
332		0
333		3
334		3
335		3
336		0
337		0
338		3
339		0
340		0
341		0
342		3
343		0
344		2
345		0

346	2
347	0
348	0
349	0
350	3
351	0
352	0
353	0
354	3
355	0
356	2
357	0
358	3
359	0
360	2
361	0
362	2

Retention juggling performance

ID	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	Mean	Min	Max	60 s trials
101	18	25	4	53	41	6	10	29	5	18	20.9	4	53	0
102	131	131	131	135	5	20	136	139	49	54	93.1	5	139	5
103	168	73	83	59	69	35	34	91	41	0	65.3	0	168	1
107	3	32	15	3	14	6	4	15	14	2	10.8	2	32	0
109	1	4	1	2	7	5	4	5	2	3	3.4	1	7	0
110	6	2	8	5	4	10	8	7	11	12	7.3	2	12	0
111	116	151	74	151	147	83	44	130	150	149	119.5	44	151	5
112	6	6	4	4	4	4	5	4	4	8	4.9	4	8	0
113	2	1	1	1	4	3	1	1	2	3	1.9	1	4	0
114	13	12	10	10	5	5	4	4	6	19	8.8	4	19	0
115	6	17	5	8	20	2	18	12	8	10	10.6	2	20	0
116	6	7	1	11	1	5	9	9	9	14	7.2	1	14	0
117	2	1	2	2	1	1	1	2	2	2	1.6	1	2	0
118	5	6	10	5	11	5	6	9	5	3	6.5	3	11	0
120	0	0	1	1	1	2	2	2	2	2	1.3	0	2	0
121	4	3	3	8	4	2	2	3	4	3	3.6	2	8	0
122	1	0	0	1	0	1	0	1	1	1	0.6	0	1	0
123	0	3	4	2	3	5	3	3	4	3	3	0	5	0
124	23	3	4	34	26	11	18	40	19	38	21.6	3	40	0
126	140	135	53	48	152	53	95	53	154	32	91.5	32	154	3

Note: Trials highlighted in yellow indicate participant reached 60 s

Transfer juggling performance

ID	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Mean	Min	Max
101	5	5	3	5	9	3	2	5	4	7	4.8	2	9
102	53	68	49	45	28	17	14	16	115	64	46.9	14	115
103	29	28	5	8	9	43	30	37	49	31	26.9	5	49
107	10	22	4	10	9	7	8	4	12	10	9.6	4	22
109	9	7	4	6	5	4	3	6	4	4	5.2	3	9
110	3	2	4	1	3	7	6	5	3	16	5	1	16
111	14	55	33	61	40	38	65	76	35	41	45.8	14	76
112	6	7	4	3	4	3	12	2	3	5	4.9	2	12
113	1	3	1	3	2	3	2	2	1	2	2	1	3
114	4	3	27	4	5	17	9	14	9	5	9.7	3	27
115	15	5	6	4	14	6	4	11	9	12	8.6	4	15
116	14	10	5	5	11	3	14	2	5	7	7.6	2	14
117	1	2	2	1	1	0	1	1	1	1	1.1	0	2
118	4	6	4	4	5	10	3	4	3	4	4.7	3	10
120	2	0	1	2	0	0	2	2	2	1	1.2	0	2
121	2	4	4	1	4	4	2	3	2	2	2.8	1	4
122	0	1	0	1	0	1	0	1	0	0	0.4	0	1
123	2	4	3	2	3	2	1	2	1	1	2.1	1	4
124	38	9	18	18	5	46	22	18	14	18	20.6	5	46
126	6	6	101	60	3	44	39	53	47	16	37.5	3	101

Individual participant responses to post-training interview questions - Rating preferences for IA

ID	Rating							
	Q1	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*
101	2	2	2	2	3	4	5	1
102	5	5	5	2	5	4	5	2
103	2	2	3	3	4	4	3	1
107	2	2	3	3	2	5	5	1
109	4	2	4	4	2	5	5	1
110	2	1	2	2	4	4	3	1
111	3	4	5	4	1	5	5	1
112	2	2	2	2	3	3	3	1
113	2	1	3	3	5	5	5	1
114	1	1	2	2	2	4	5	1
115	2	5	2	5	1	4	4	3
116	5	5	5	3	2	4	5	1
117	4	5	5	3	1	5	5	1
118	2	1	3	3	4	5	4	3
120	2	1	4	4	3	4	3	2
121	2	2	2	2	5	5	5	1
122	3	4	1	1	2	4	3	1
123	4	3	3	2	2	5	4	1
124	2	2	3	4	2	4	5	1
126	1	1	5	5	1	5	5	1

1 = *never*, 2 = *seldom*, 3 = *occasionally*, 4 = *often*, 5 = *always*

Participant responses to open-ended questions about use instructions (I), use of demonstration (D), use of feedback about technique (KP), use of feedback about juggling duration (KR), goal-related behaviors (G), strategies (S), proficiency (P), thoughts on quality of assistance (IA), and additional thoughts on experience (O)

ID	Item	Response
101	G	Tried to do better than my previous performance time wise. At first I just wanted to get it.
101	IA	Sure I could have used more but I don't know what.
101	KP	To get better & to figure out what I was going wrong
101	KR	To confirm what I thought.
101	P	Yes. Day 3. Middle of day 3.
101	S	The tips.
102	D	I didn't want to go through all the instructions but I wanted to see the difference. I didn't need the whole set of instructions.
102	G	I just wanted the count to keep increasing. There is no ending to end it. I just tried to go farther and farther as much as possible.
102	I	To try to figure out what am I doing wrong and comparing it to previous attempt. I asked for the instructions multiple times because I still hadn't got the concept yet.
102	IA	The most helpful was the time. The time was keep motivating you. I could just feel that I am doing better and better. Until you feel like you are getting better I didn't ask for time. Once I started to get it, I started asking for time.
102	KP	I was always looking for some little difference that I am doing compared to the actual thing. I was trying to figure out what's the little thing that I am making a mistake on. I can't figure those out by myself.
102	KP	Asked for tips to identify aspects of performance that I couldn't see on my own.
102	KR	When I do well I asked for the time so I had an idea of the maximum time I had spent. If a trial was lower than that, there wasn't a point to ask. Because I kept count, I also wanted to get a sense of how my count related to the time and how that varied by the way I threw the balls. If I toss it longer, I can throw it for a longer time. By throwing it higher I can make the time longer because I can complete more throws now.
102	O	While I was juggling, my body balance was important. Not just the toss and catching but also keeping your balance in the middle.
102	P	It wasn't at 20 catches. Instead, it was at 40 or 50 catches before I felt like I was really in control of it.
102	S	Counting each tosses. The higher number motivated me. After I reached 70 I kept trying to go higher and higher. Initially, I looked at the instructions and tried to copy the movement in the video. Tried to look at how the tosses were moving. Once I got it I used the counting to motivate me to improve.
103	G	No. I focused on the technique.
103	IA	Simple and straightforward. At first, the instructions were most helpful. After that was the demo. After that was the time and the juggling tips. I didn't feel I had a good sense of the time.

103	KP	I wanted to see what I was doing correctly and to make sure that what I was doing was correct.
103	KP	Trying to find out what I was doing wrong.
103	KR	I wanted to know where I was in my progress. I could figure out when it was poor so I didn't need to ask about that.
103	O	Maybe a combination of the demo and instructions so there could be a step by step set of moving instructions.
103	P	Yes. Almost at the end of Day 3. I could tell by the longer trials.
103	S	I don't think anything that I cam e up with. The most important thing was the instruction part and keeping it like a wall. I used the instructions and keyed on what was highlighted.
107	D	After I found what I was trying to do I watched the demo to see what your hands were doing. I saw that your were watching the ball so I said 'okay' I need to focus on that.
107	G	First goal was 3 balls. 10s and then wanted to go for 15s.
107	I	I used it for the first day or two to get the gist of what I am doing. Not tied to individual attempts but just to get a sense of the movement.
107	IA	The best thing was the tips. I never would have gotten it without that. I never would have figured out I actually had to watch the balls above my head.
107	KP	I didn't know how to catch it and asked for a tip. I didn't know how to throw it and asked for a tip. Really any kind of issue. I asked for tips to resolve them and learned how to juggle.
107	KR	It helped me gauge my improvement and set new goals.
107	P	I feel that I currently am kind of proficient. It was when I could pass 10s.
107	S	I would try to see what my issues were and resolve them. Diagnose errors and fix them. Moved from how to throw and then it changed as I had new problems. I first tried to fix it and then would call for a tip if I couldn't.
109	D	To refresh my memory on where the ball was in relation to the body or how you were throwing it.
109	G	The first couple of days went well and the next couple of days I wanted to keep progressing but I didn't really. I guess it was to try to fix my flaws.
109	I	I used it to get a baseline and see how it is done. To see what to do.
109	IA	The instructions were useful for me to get a baseline for how it was supposed to be done and the demo was helpful for reminding me of what it looked like. The tips were helpful when I kind of knew what I was doing wrong but needed some help. I would have liked to have an option to break it down into a part practice situation.
109	KP	When I felt like what I was working on on my own I wasn't getting anywhere with.
109	KR	It was never necessary.
109	O	I thought it might be helpful to discuss how to release the ball at first. But then I noticed that there isn't really a technique and your hands will do what they need to do.
109	P	I don't think I did. When I didn't feel like a long period of juggling was a fluke. Most of the time I felt like I was just getting lucky. It wasn't because I had great

		technique.
109	S	Not really. I never seem to be able to do what I intended so I just kept practicing to try to get the feel for it.
110	D	To see how it was done. To figure out what I was doing wrong and how to keep it going once I got started.
110	G	Not really I guess. Aside from just being able to get all 3 out of my hands. Complete a full cycle. Honestly I was set on getting past 5 seconds yesterday. Today I was thinking maybe 10.
110	I	I just wanted to know where to get started.
110	IA	The instructions were really helpful for getting started. And then the demo helped me see how it was done. The tips helped a ton after I got a little bit better.
110	KP	The first time it helped me progress – get started. After that it was to improve what I was doing wrong because I am sure there was something I was doing wrong.
110	KR	I wanted to know how much I could do and not what I was not doing.
110	P	No. When I could consistently get them up for 10 seconds.
110	S	On day 1 I repeated left right in my head. Today I kept saying up up up in my head.
111	D	I like to view things and copy it.
111	G	I didn't think I could get over a minute. That was my goal. Probably beginning of Day 3 I targeted the one minute mark.
111	I	In my thought process, I feel like looking at it more. I think the demo helped me more. I like viewing it and watching how someone does it. But the instructions did help. They pointed out the Figure 8. I think the 2 that helped that most were the juggling tips and the demo, to me. But the instructions did point out 1 or 2 other things that I didn't see otherwise.
111	IA	That is really how it helped me the most (demo). To other people, the instructions would help a lot too. For me, the demo and the tips helped me the most by far. At the very beginning you juggled yourself in person. If I had a live person demo it would help me a lot. My first attempt was based on your instruction and demo on the first day.
111	KP	Basically when I felt like I wasn't doing something right or it didn't look the same as the demo.
111	KR	Confidence.
111	O	Maybe for the instructions. I didn't pay attention to that all that much. For what I learned, the demonstration was the main thing. If there is a demonstration available and someone to give you feedback you should be able to learn it.
111	P	Day 3 I felt more consistent. I got my throws down more. Maybe the 2nd day too because you told me I was going like this [circle pattern]. I would say 10-15 seconds. When you fully get the cycles going. Say I have one pink ball and 2 green. I will watch the pink ball go around just to keep me preoccupied. So I could tell what cycle, how far along I was. If it goes around more than 2x you could probably keep going with it. When it smacks my hand, I would try to listen to that and make it sound as consistent as I can. If it is not consistent then I know I am throwing it too late or too early. I would watch the balls go around too.

111	S	I tried to look at it and copy it and follow the Figure 8 pattern. They did because my original movement pattern was incorrect. I trusted the instructions to lead to better performance.
112	D	Just to give me a visual of how it looks.
112	I	Just so I would have like propoer instruction to start out with so I wouldn't be starting out with something wrong.
112	IA	It was all really good. Not really anything else.
112	KP	To figure out what to work on next to continue to get better.
112	KP	I wouldn't know if I was doing something wrong because I am not trained.
112	KR	So I could know where to set my next goal.
112	P	Somewhat. Day 3.
112	S	Just to do it repetitively a lot and once I found a certain pattern to stick with it. And when I started doing poorly I would stop myself and tell myself "throw' in my head to make myself throw. Not really changing.
112	S	Kind of. Once I got in a really good set. Try to do that again or something close. Always try to repeat my progress. Not really changing.
113	D	When I was wanting to visually see it
113	G	I wanted to get it. I wanted to test well tomorrow so that was a goal. 5-10 seconds. They went down a little each day. From 10 to 5 seconds.
113	I	I used the instructions to sort of like look at technique but after day 2 when I got the technique down I didn't need it anymore
113	IA	The juggling tip was like the best for me.
113	KP	Usually if I did something really bad, unless it was just a mistake like a drop, just to get me on the right track again. And when I was almost getting it I would ask for tips so I could fully get it.
113	O	Not really because it just takes practice. You can only watch that stuff so many times. You just have to practice.
113	P	For 4 days I think I did. I feel like I could have done better if I had more time. Got it more yesterday than today.
113	S	Definitely the tip of throwing up higher and keeping your eyes up. The tempo is a lot slower than I thought it was.
114	D	I just needed to see one time how you juggled yourself.
114	G	I always strived to do better on the next attempt than the previous. My goal was to go for a minute but that was a false promise. I adjusted that with the rate that I was learning. About 30 seconds would really please me.
114	I	I learn better by monkey see monkey do which the demo provided. The demo worked awesome.
114	IA	I would have to say that the demo helped out a lot by basically seeing how your hand moves and the rate that you catch and release. And also with the instructional tips I would hear it but mold it into my own form of what I had already known rather than start all over. The time was more for confidence base.
114	P	I can go in short bursts but in those bursts do pretty well. Today was the day I felt I was proficient and I could repeat results. I could go for 10+ for multiple times in a row.
114	S	Get a pattern that works well in my mind and my hands and mimic that through

		the juggling. Looked it as a whole rhythm. I tried to change but always saw myself as naturally going into my comfortable rhythm. I guess I would just say it was what I was comfortable with.
115	G	Just set them higher every day.
115	IA	I thought that they were helpful. Tips and time were usually the most useful.
115	KR	Just wanted to see if I was improving or at least maintaining.
115	P	No. Needed more time. 15 seconds is where I would have had to get.
115	S	No.
116	D	Just trying to see what exactly that you might be doing.
116	G	Always wanted to get a couple seconds longer than before. I thought that by today I should be at like 30 seconds.
116	IA	I thought they helped. There at the beginning I didn't even know what to do.
116	KP	I just wanted to see what I was doing wrong.
116	KR	I wanted to see when I did well so I could do more of what produced those trials.
116	O	Maybe if I could have asked for questions instead of just tips.
116	P	No. At least 30 seconds. Being able to do it until I didn't want to basically. 2 more weeks like this to get to that level.
116	S	No not really. Just trying to do exactly what the instructions and demo showed.
117	D	Just to see the difference between what I thought – how I was doing it in my head – and seeing it.
117	G	At least a baby step better than the day before. Day 1: throwing 3 balls catch at least 2. Day 2: have the balls land close to me. Day 3 and 4: catch all the balls.
117	I	Definitely to correct because I wanted to see if there was anything I was missing and what to do better.
117	IA	I thought the instructions were very helpful and the juggling tip was very helpful. I think for the scale of people the demo was helpful but I am not much of a visual learner and am not very coordinated. I don't know how helpful time is to learning.
117	KP	If I would be juggling and I got a specific spot where I could tell something was wrong but I couldn't figure out what it was – like when you told me I was switching under I didn't realize I was going that.
117	KR	I would have asked to see that I was going well and not poorly.
117	P	If I had a little more time like yesterday because I felt like I progressed the most yesterday. But coming back is like starting at square 1. If yesterday I could catch all 3 balls and juggle them at least once I felt like I would have been okay.
117	S	As I went along because I didn't come in with a strategy. If I did something well once I would try to replicate. And I tried to always do a little better than the day before even if I never learned to actually juggle.
118	D	Just to follow the pattern and watch someone else do it.
118	G	Goal was to make it to 5 seconds. My first goal was to toss and catch without looking at it – I didn't think that was possible. Once I could do that I wanted to make it to 5.
118	I	Just to get started.
118	IA	It was all good.
118	KP	Maybe you could see something that I couldn't see. Cause I am just thinking

		about my throwing.
118	KR	Because I thought I was doing well.
118	P	No. Well, yes. Defined: Be able to start it is proficient. Carrying on with it is different. I am comfortable with starting it.
118	S	None.
120	D	Well the first time I wanted to see a full demo because there wasn't one on the video. The other times I was watching for specific reasons: how you threw it, when you let go, etc.
120	G	I wanted to – each day I had a task. I always tried to change my goal to next level. I keep catching the 3rd I would go to throwing it.
120	I	Well the first time I wanted to get an idea of what other things I should focus on and a full range of what I was supposed to do. I asked on the 3rd day to refresh my memory and remind myself of the keys.
120	IA	The video was helpful for a basic guideline and to use a refresher. I don't think it would help over and over again. As for the tips, those are awesome. I need feedback when I learn so I can figure out what I am doing wrong. The demo also helps because I am a visual learner so I could see it and try to imitate it to get the rhythm.
120	KP	I thought that I would be doing something right but wasn't sure so I would ask to figure out a reason behind it.
120	O	More time to practice would have been most helpful. I was also getting frustrated and then bored as a result. I don't think 40 minutes was enough time for each day.
120	P	Well I could never get to the timed section so I would say no. I was getting there but I wasn't at that level. In a few more days I think I would have figured it out. I was always moving forward. I would say 5 seconds.
120	S	My main strategy was the colors. I ordered them so I could track where they were going and when I was letting go of them. That was the best strategy. At first – I didn't do that until day 2 – I was just trying to get the hang of them but it felt too random and I needed a focus so I went with the colors. I also would make sure the first toss was good before continuing with the other ones.
121	D	I thought the demo was easier without the talking (because I got confused)
121	G	I wanted to juggle. Really it was get past certain goals: throwing the 3rd, 5th and 6th catch.
121	I	Just to see the flow of it.
121	IA	I like the instructions they were okay but I like text. Like Step 1 you throw from one hand to the other. I am hearing them say it but I am not taking anything out of it because I can't read the text. The demo I just watched and followed. A table would have been good to be in front of you because picking up the balls got old.
121	P	No. It depends. I know more about juggling now than I did when I started. I feel like you would need a minute worth to say you were good. But 15 seconds would give you enough proof to show people.
121	S	I tackled each segment. If I messed up I would go back to the one prior. I stuck with segmentation for a while but toward the end of yesterday and today I just went for it. Instead of going back if I failed I just jumped back in where I was.
122	D	I think the instructions gave me more detail. It is hard for me to just copy.

122	G	I tried to catch at least 2 balls because I was only able to catch one and I failed. General goal of wanting to get better but not specific goals.
122	IA	I think they were very helpful. On the instructions I can actually see how to do it in slower motion and see how you should position your hands and the cycle of the ball. The tips helped me to correct my mistakes and told me what I could do to improve.
122	O	A mirror or some way of seeing myself. To compare what you do with your own performance
122	P	No. I would need a lot more practice. You should be able to juggle for at least 30 seconds to be called proficient.
122	S	I didn't really plan anything. I just asked for help when I felt I needed it.
123	D	I just watched it to get technique down.
123	G	I was trying to get to next ball every day. If I got there I was succeeding. After the first day I didn't think I was going to get it at all but gradually I made the steps.
123	I	I always felt like I would get something that I was missing if I watched it.
123	IA	Asking you what I was doing was the most helpful. Maybe if I could actually watch myself do it because I could see what I was doing. Watching in the mirror sometimes works but in this case if I am watching my eyes would be in the wrong place.
123	KP	I couldn't see what I was doing but you could so I figured you would know what was going on.
123	P	I feel like I am close. In one more day it will either click or I wasn't going to get it. The last throws were going in the right direction but the time was off. I know now what I am doing so it is just doing it.
123	S	Hand technique. Trying to get my hands to release balls, learn movement pattern. It changed based on number of balls I was at.
124	D	Just wanted to see somebody better doing it.
124	G	I wanted to get to 20 seconds. After Day 3. The first few days I was at like 5 seconds but didn't think I was going to get that.
124	I	I wanted to see form.
124	IA	I believe they were helpful to an extent. Watching someone do it who was better than me allowed me to know what I needed to do right and tips allowed me to know what I was doing wrong. And time helped me push myself to increase my time.
124	O	The wall got in the way a bit. I would have liked the hoop to be in the middle.
124	P	Day 4. After a while I got to 10 seconds consistently. I started getting that consistently instead of 5s and occasionally an 8.
124	S	I counted each throw in my head. Sometimes I would focus on the colors instead. So I would just track colors. And then I went to numbers. I started with colors and finished with numbers.
126	D	I learn by watching people. If you can do it and I can figure out what you are doing that I am not doing then I can fix that.
126	G	I came in with the goal of learning how to juggle and when I was here and got the idea I just started at 100. And then 200. And then 300. And at 500 I was bored.
126	I	I do better working out by myself...If I hadn't gotten it I would have probably

		looked at it but turned the sound off.
126	IA	In my experience, once I get something if somebody tries to explain it to me again it is going to annoy me or confuse me and I don't want to do either one because I don't like getting mad at people and I don't like getting confused. So the demo was definitely my favorite one and would be my favorite one for anything because if I can see you do it then I can mimic that. And if doesn't work then I can ask you what did you do that I didn't see. Time is just a gauge. Instructions. Some people are screen learners. But I don't like looking at a screen more than I have to. I think that learning is a decision. So if I come in and I have already decided that I am not going to be able to get it then I am not going to be able to get or I am going to have a very hard time with it. If I come in and I say I am going to watch you, if I have a question I'll ask but otherwise stay out of my way then that puts me in a mentality of its up to me – I am not relying on you. And that works better for me.
126	KP	When I asked for a demo I asked what I was doing wrong. When I ask for a tip I don't want somebody to come up and give me a paragraph. One or two things is okay. Which is what you did. This is what works for me so you try it. Try looking up. Try imaging the wall. The wall didn't really help but looking up did.
126	KR	I figured I was hitting somewhere around 30 seconds for most average...I felt confident enough that I could up that if I needed to. So if it didn't really matter to me I figured I could just get as good as I could. If I did something like the 500 I was like "how long was that?' so I would have a gauge.
126	O	If I was going to try to teach somebody something. I would give them the basic understanding and then have them teach somebody else. When you teach somebody else that is where you really see where your flaws are and you can improve and that makes you a whole lot better even if you didn't teach them that well. It's not helpful to think about things when you are doing it. You just have to do it.
126	P	Like I can do this forever? Ummm...I mean I still feel like I could potentially mess up...I could answer "yes' to "can you juggle?' at the end of Day 1. It wasn't a particular number. When I hit 100, that's just my mentality that 100 is the goal to hit. But 50 I would say "yeah I could juggle.' I feel like you only have to it 10 to 20 times in most cases.
126	S	Just don't focus. I didn't focus very hard. I didn't get caught up in "Friday I am going to have to do this 10 times.' Don't worry about - I didn't worry about it. Once I understand it I just practice it and don't worry about it. You saw the counting. I would ask you questions so we could talk a little bit so I wasn't thinking "right hand, left up, over, under.' If I thought like that I would drop it every time. What I do is I don't focus on it. I don't overthink it. I don't worry about the outcome.

Appendix E

Tables and Figures

Table 1. Total number of juggling attempts and mean number of catchers per attempt for late, emerging, and proficient learners during acquisition, retention, and transfer

Participant	Total attempts	Mean number of catches per attempt						
		Day 1	Day 2	Day 3	Day 4	ACQ	RET	TRN
Late learners								
113	964	1.6	2.1	2.7	2.3	2.1	1.9	2.0
117	385	1.1	1.5	1.1	0.9	1.1	1.6	1.1
120	1330	1.1	0.9	0.5	0.8	0.8	1.3	1.2
121	1565	1.2	1.4	2.1	2.0	1.5	3.6	2.8
122	906	0.5	0.5	0.6	0.6	0.5	0.6	0.4
123	677	0.8	1.5	2.1	2.0	1.7	3.0	2.1
Group M	971.2	1.1	1.3	1.5	1.4	1.3	2.0	1.6
Group SD	*428.0*	*0.4*	*0.6*	*0.9*	*0.7*	*0.6*	*1.1*	*0.9*
Emerging learners								
107	584	1.3	2.2	2.7	6.3	3.2	10.8	9.6
109	816	2.3	3.2	3.5	3.7	3.2	3.4	5.2
110	826	2.1	4.7	5.7	5.5	4.7	7.3	5.0
112	1399	2.7	2.8	2.8	3.3	2.8	4.9	4.9
114	703	2.9	5.2	6.5	9.3	5.7	8.8	9.7
115	1034	2.0	2.5	5.8	6.4	4.2	10.6	8.6
116	1080	1.5	2.4	3.4	4.4	3.1	7.2	7.6
118	937	1.5	1.8	3.0	2.9	2.3	6.5	4.7
Group M	922.4	2.1	3.1	4.2	5.2	3.7	7.4	6.9
Group SD	*253.0*	*0.6*	*1.2*	*1.6*	*2.1*	*1.1*	*2.6*	*2.2*
Proficient learners								
101	614	2.4	5.1	9.2	9.4	6.9	20.9	4.8
102	393	2.3	8.9	23.7	77.8	15.0	93.1	46.9
103	526	3.1	4.9	8.7	22.6	8.0	65.3	26.9
111	284	5.4	12.2	29.0	67.1	19.1	119.5	45.8
124	1134	2.2	2.7	4.9	11.6	4.5	21.6	20.6
126	321	6.6	32.5	72.0	111.6	25.2	91.5	37.5
Group M	545.3	3.6	11.1	24.6	50.0	13.1	68.7	30.4
Group SD	*314.1*	*1.9*	*11.0*	*25.1*	*41.8*	*8.1*	*40.5*	*16.3*

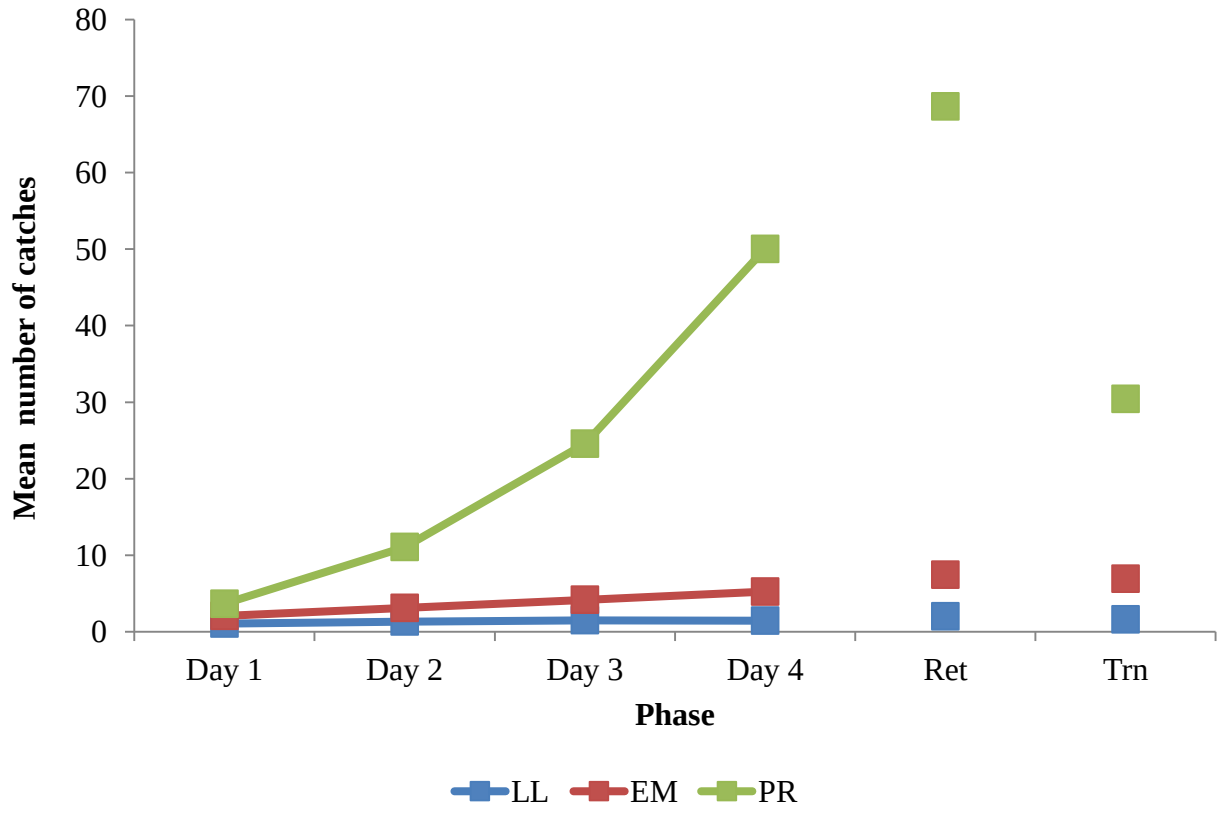

Figure 1. Mean number of catches for each group across the four days of acquisition, retention, and transfer

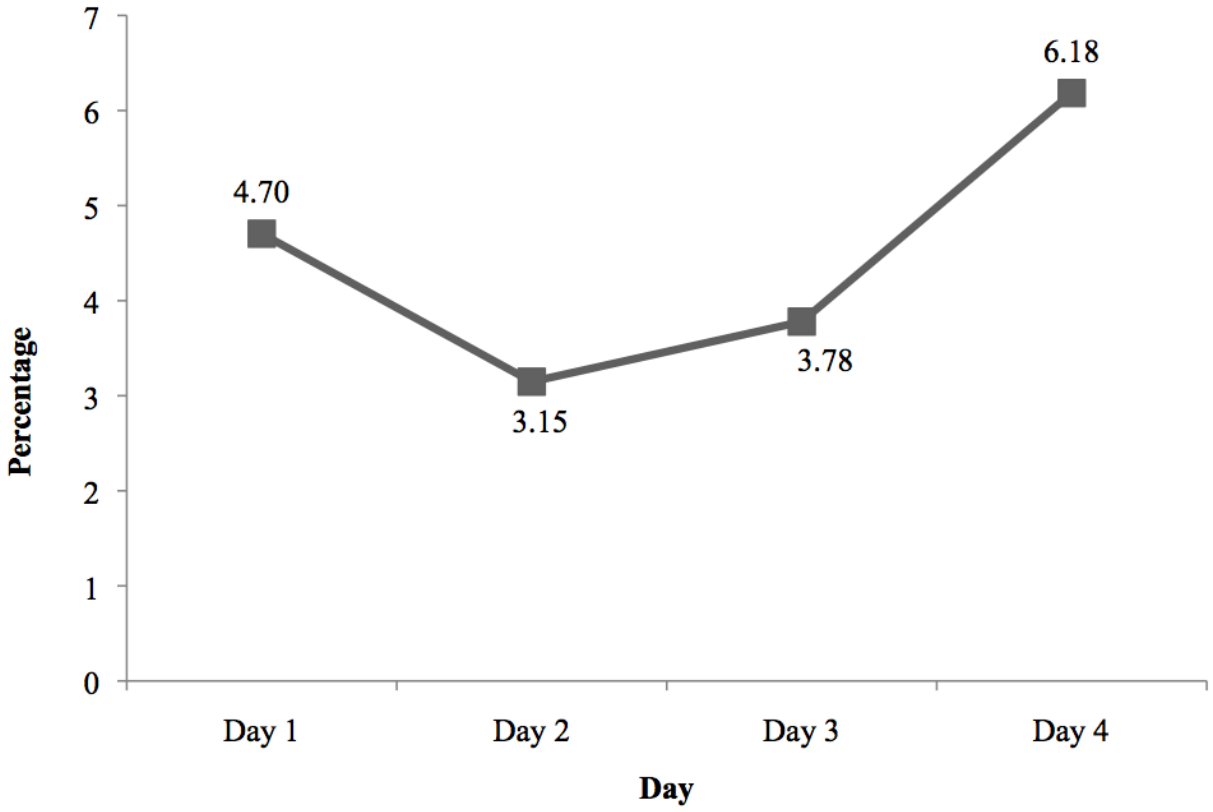

Figure 2. Total IA requests as a percentage of attempts during each day of acquisition

Table 2. IA request percentages for late, emerging, and proficient learners during each day of acquisition and across practice

Participant	Request percentage				Total request percentage across practice
	Day 1	Day 2	Day 3	Day 4	
Late learners					
113	1.2	0.4	0.5	1.1	0.7
117	4.0	2.8	2.2	0.9	2.3
120	0.6	1.4	1.8	0.3	1.0
121	2.3	0.8	0.2	0.9	1.0
122	2.0	1.3	0.8	0.8	1.2
123	17.6	15.3	11.6	6.6	12.0
Group M	4.6	3.7	2.9	1.8	3.0
Group SD	6.5	5.7	4.4	2.4	4.4
Emerging learners					
107	11.2	2.5	3.4	3.4	4.5
109	1.2	1.9	0.4	1.0	0.9
110	1.8	0.0	0.8	0.6	0.7
112	1.5	0.0	0.4	0.6	0.6
114	0.5	2.1	1.0	1.4	1.1
115	4.7	2.8	11.1	8.3	6.6
116	2.5	1.2	3.0	2.3	2.2
118	6.3	1.5	3.6	3.5	3.0
Group M	3.7	1.5	2.9	2.6	2.4
Group SD	3.6	1.1	3.5	2.6	2.1
Proficient learners					
101	3.1	3.4	4.3	3.2	3.6
102	6.0	8.0	10.8	50.0	10.7
103	6.9	3.9	1.7	6.3	4.0
111	15.3	10.4	11.4	13.0	12.3
124	3.8	2.1	4.3	7.0	3.8
126	1.6	1.1	2.3	0.7	1.9
Group M	6.1	4.8	5.8	13.4	6.0
Group SD	4.9	3.6	4.3	18.4	4.3

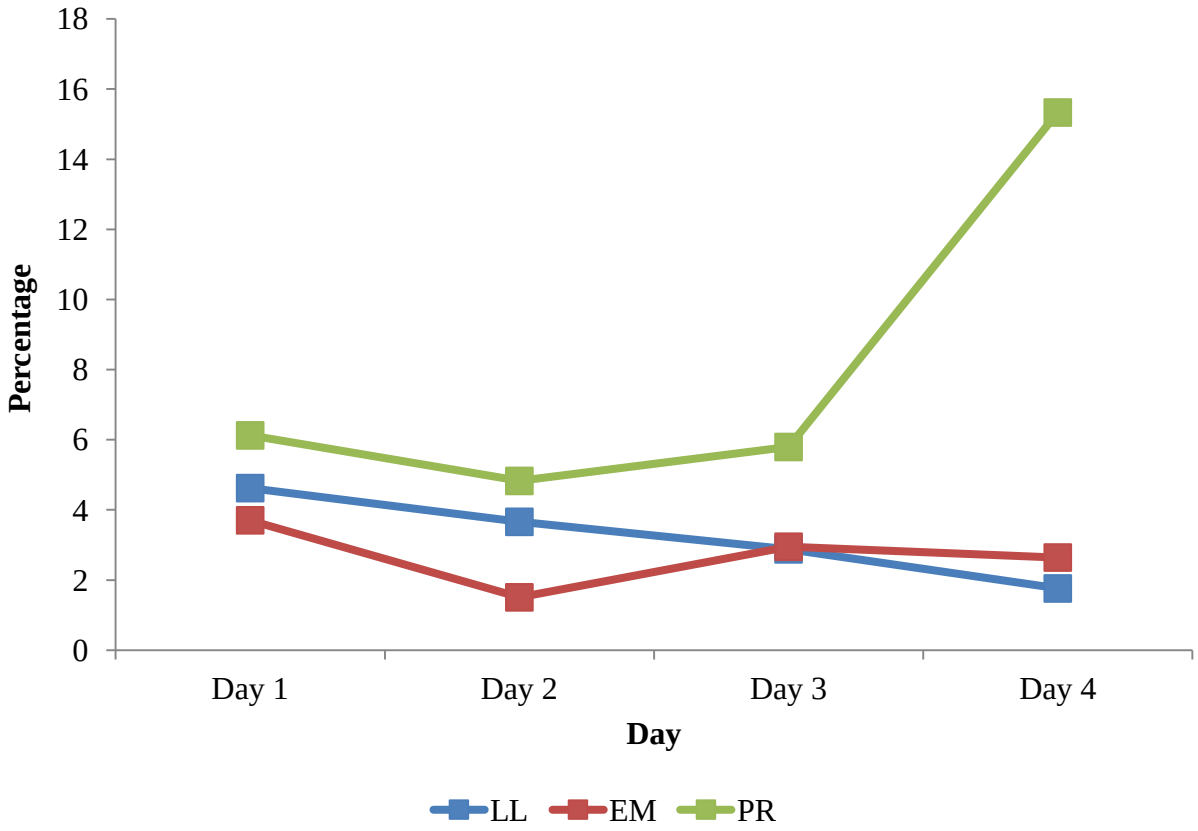

Figure 3. IA request percentages for Late, Emerging, and Proficient learners during each day of acquisition

Table 3. Request percentage for each type of IA during four days of acquisition for all participants

	Request percentage			
	Day 1	Day 2	Day 3	Day 4
Instructions (I)	0.8	0.2	0.1	0.0
Demonstration (D)	0.7	0.3	0.1	0.1
Feedback about technique (KP)	2.6	1.7	1.5	0.9
Feedback about duration (KR)	0.6	1.0	2.2	5.2

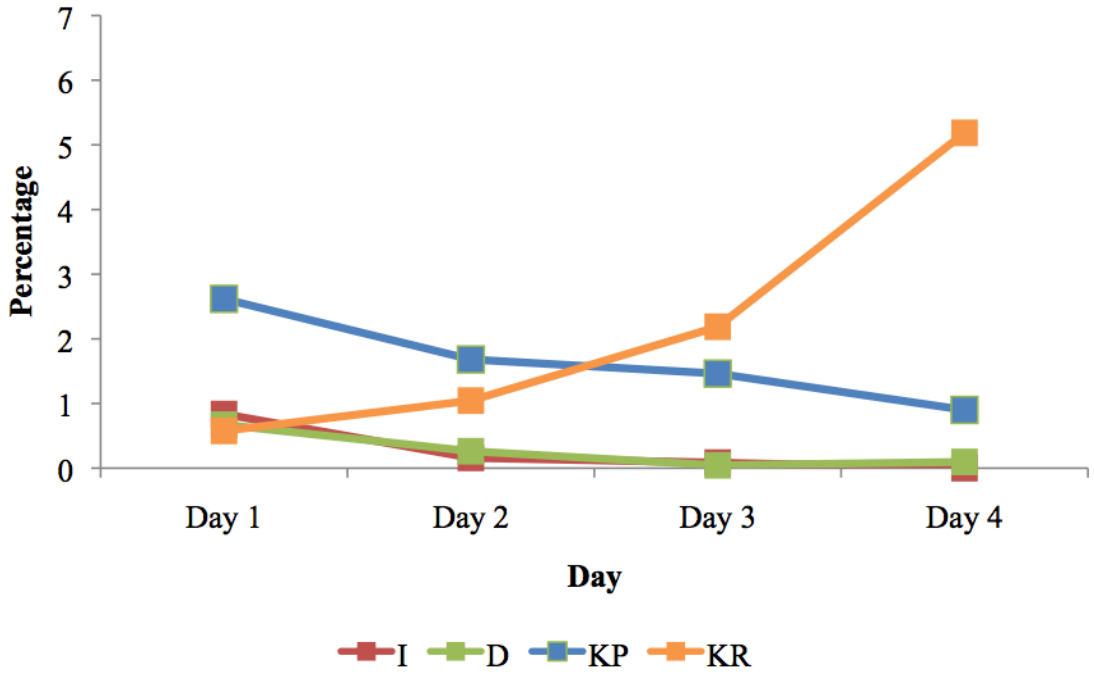

Figure 4. Request percentage for each type of IA during four days of acquisition for all participants

Table 4. Instruction (I) request percentages for late, emerging, and proficient learners during each day of acquisition and across practice

Participant	Request percentage			
	Day 1	Day 2	Day 3	Day 4
Late learners				
113	0.3	0.0	0.0	0.0
117	0.0	0.9	0.0	0.0
120	0.3	0.0	0.3	0.0
121	0.3	0.2	0.0	0.0
122	0.5	0.4	0.0	0.0
123	3.9	1.1	0.6	0.0
Group M	0.9	0.4	0.1	0.0
Group SD	1.5	0.5	0.2	0.0
Emerging learners				
107	2.0	0.0	0.6	0.0
109	0.6	0.0	0.0	0.0
110	0.6	0.0	0.0	0.0
112	0.4	0.0	0.0	0.0
114	0.0	0.0	0.0	0.0
115	0.9	0.0	0.0	0.0
116	0.8	0.0	0.3	0.0
118	1.1	0.0	0.0	0.0
Group M	0.8	0.0	0.1	0.0
Group SD	0.6	0.0	0.2	0.0
Proficient learners				
101	0.8	0.0	0.0	0.0
102	1.7	0.0	0.0	0.0
103	1.0	0.6	0.0	0.0
111	1.2	0.0	0.0	0.0
124	0.4	0.0	0.0	0.0
126	0.0	0.0	0.0	0.0
Group M	0.8	0.1	0.0	0.0
Group SD	0.6	0.2	0.0	0.0

Table 5. Video demonstration (D) request percentages for late, emerging, and proficient learners during each day of acquisition and across practice

Participant	Request percentage			
	Day 1	Day 2	Day 3	Day 4
Late learners				
113	0.3	0.4	0.0	0.6
117	0.0	0.9	0.0	0.9
120	0.3	0.7	0.3	0.0
121	0.3	0.0	0.0	0.0
122	0.0	0.0	0.0	0.0
123	1.0	1.1	0.6	0.0
Group M	0.3	0.5	0.1	0.2
Group SD	0.4	0.5	0.2	0.4
Emerging learners				
107	2.0	0.6	0.0	0.0
109	0.6	0.0	0.0	0.5
110	0.6	0.0	0.0	0.0
112	0.4	0.0	0.0	0.0
114	0.5	0.0	0.0	0.0
115	0.9	0.3	0.0	0.0
116	0.0	0.3	0.0	0.0
118	2.1	0.0	0.0	0.0
Group M	0.9	0.2	0.0	0.1
Group SD	0.8	0.2	0.0	0.2
Proficient learners				
101	0.8	0.0	0.0	0.0
102	0.0	0.7	0.0	0.0
103	2.0	0.0	0.0	0.0
111	1.2	0.0	0.0	0.0
124	0.0	0.3	0.0	0.0
126	0.5	0.0	0.0	0.0
Group M	0.8	0.1	0.0	0.0
Group SD	0.6	0.2	0.0	0.0

Table 6. KP request percentages for late, emerging, and proficient learners during each day of acquisition and across practice

Participant	Request percentage			
	Day 1	Day 2	Day 3	Day 4
Late learners				
113	0.6	0.0	0.5	0.6
117	4.0	0.9	2.2	0.0
120	0.0	0.7	1.2	0.3
121	1.7	0.6	0.2	0.4
122	1.5	0.9	0.8	0.8
123	12.7	13.2	10.5	6.1
Group M	3.4	2.7	2.6	1.4
Group SD	4.8	5.1	3.9	2.3
Emerging learners				
107	7.1	1.9	2.8	0.7
109	0.0	1.3	0.4	0.5
110	0.6	0.0	0.4	0.6
112	0.4	0.0	0.2	0.3
114	0.0	0.7	0.0	0.0
115	1.9	1.3	0.4	0.9
116	1.7	0.6	0.0	0.0
118	3.2	1.5	2.4	1.5
Group M	1.9	0.9	0.8	0.6
Group SD	2.4	0.7	1.1	0.5
Proficient learners				
101	0.8	0.7	0.0	0.6
102	3.4	0.7	1.0	0.0
103	3.0	1.7	1.7	4.7
111	5.9	6.6	4.3	0.0
124	3.4	0.5	0.3	0.0
126	0.5	0.0	0.0	0.0
Group M	2.8	1.7	1.2	0.9
Group SD	2.0	2.5	1.6	1.9

Table 7. KR request percentages for late, emerging, and proficient learners during each day of acquisition and across practice

Participant	Request percentage			
	Day 1	Day 2	Day 3	Day 4
Late learners				
113	0.0	0.0	0.0	0.0
117	0.0	0.0	0.0	0.0
120	0.0	0.0	0.0	0.0
121	0.0	0.0	0.0	0.4
122	0.0	0.0	0.0	0.0
123	0.0	0.0	0.0	0.5
Group M	0.0	0.0	0.0	0.2
Group SD	0.0	0.0	0.0	0.2
Emerging learners				
107	0.0	0.0	0.0	2.7
109	0.0	0.6	0.0	0.0
110	0.0	0.0	0.4	0.0
112	0.4	0.0	0.2	0.3
114	0.0	1.4	1.0	1.4
115	0.9	1.3	10.7	7.5
116	0.0	0.3	2.7	2.3
118	0.0	0.0	1.2	2.0
Group M	0.2	0.4	2.0	2.0
Group SD	0.3	0.6	3.6	2.4
Proficient learners				
101	0.8	2.8	4.3	2.5
102	0.9	6.7	9.8	50.0
103	1.0	1.7	0.0	1.6
111	7.1	3.8	7.1	13.0
124	0.0	1.3	4.0	7.0
126	0.5	1.1	2.3	0.7
Group M	1.7	2.9	4.6	12.5
Group SD	2.6	2.1	3.5	18.9

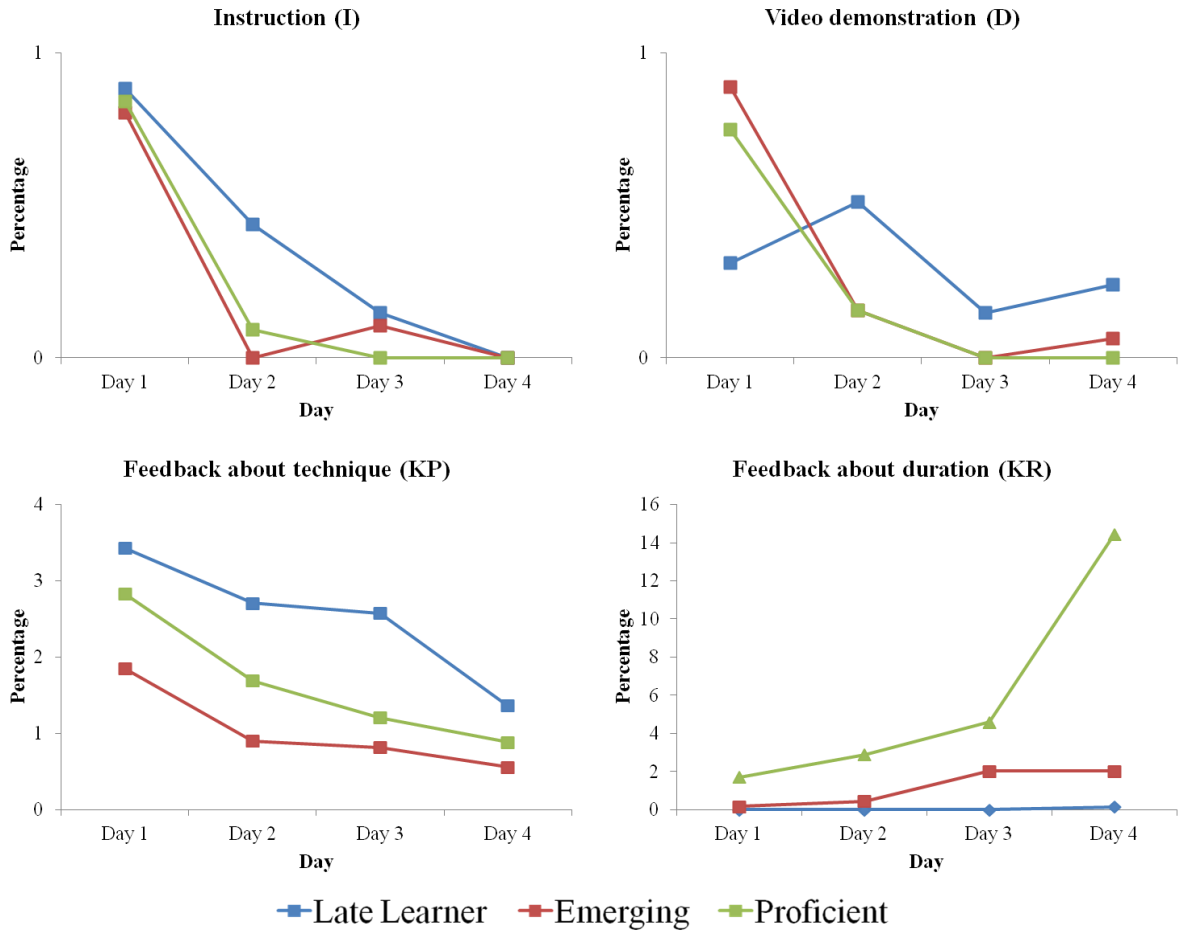

Figure 5. Request percentages for each type of IA during four days of acquisition for Late, Emerging, and Proficient Learners

Table 8. Mean response to post-training interview questions regarding IA preferences for Late, Emerging, and Proficient Learners

Interview question		Group mean		
		LL	EM	PR
1.	How often did you ask for instructions to provide ***guidance*** for the upcoming attempt?	2.8	2.5	2.5
2.	How often did you ask for instructions to provide ***correction*** for the previous attempt?	2.7	2.4	2.7
3.	How often did you ask for video demonstrations to provide ***guidance*** for the upcoming attempt?	3.0	2.9	3.8
4.	How often did you ask for video demonstration to provide ***correction*** for the previous attempt?	2.5	3.0	3.3
5.	How often did you ask for feedback about your technique when you thought your juggling was relatively ***good***?	3.0	2.5	2.7
6.	How often did you ask for feedback about your technique when you thought your juggling was relatively ***bad***?	4.7	4.3	4.3
7.	How often did you ask for feedback about your time when you thought your juggling was relatively ***good***?	4.2	4.3	4.7
8.	How often did you ask for feedback about your time when you thought your juggling was relatively ***bad****?*	1.2	1.5	1.2

1 = never, 2 = seldom, 3 = occasionally, 4 = often, 5 = always

Table 9. Total number of participants who indicated each response category for the post-training interview questions regarding IA preferences

Interview question		Count				
		1	***2***	***3***	***4***	***5***
1.	How often did you ask for instructions to provide ***guidance*** for the upcoming attempt?	2	11	2	3	2
2..	How often did you ask for instructions to provide ***correction*** for the previous attempt?	6	7	1	2	4
3.	How often did you ask for video demonstrations to provide ***guidance*** for the upcoming attempt?	1	6	6	2	5
4,	How often did you ask for video demonstration to provide ***correction*** for the previous attempt?	1	7	6	4	2
5.	How often did you ask for feedback about your technique when you thought your juggling was relatively ***good***?	4	7	3	3	3
6.	How often did you ask for feedback about your technique when you thought your juggling was relatively ***bad***?	0	0	1	10	9
7.	How often did you ask for feedback about your time when you thought your juggling was relatively ***good***?	0	0	5	3	12
8.	How often did you ask for feedback about your time when you thought your juggling was relatively ***bad****?*	16	2	2	0	0

1 = *never,* 2 = *seldom,* 3 = *occasionally,* 4 = *often,* 5 = *always*

Table 10. Participant descriptions of how and why they chose to use each form of IA during the four days of acquisition

IA	Theme	Count
Instructions	*To understand general concept*	8
	To obtain unique information	2
Demonstration	*Preferred visual information*	6
	Wanted specific information	3
KP	*To highlight undetected errors*	10
	To address specific problems	3
KR	*To confirm improvement*	10
	To connect technique & performance	3
	To gain confidence & enhance motivation	3

Table 11. Participant descriptions of goal-related behaviors and strategy use during the four days of acquisition

Interview topic	Theme	Count
Goals	*Ultimate improvement*	8
	Incremental improvement	7
	General improvement	3
	Perfect technique	1
	None	1
Strategies	*Attentional focus*	8
	Emulation	6
	Practice structure	5
	None	4

Table 12. Participant self-efficacy scores and group means for Late, Emerging, and Proficient Learners throughout acquisition, retention, and transfer

Participant	Score			
	Pre ACQ	6	12	Pre TRN
Late learners				
113	0	8	-	1
117	2	-	-	2
120	2	-	-	4
121	0	4	-	2
122	0	-	-	1
123	3	-	-	10
Group M	1.2	6.0	-	3.3
Group SD	*1.3*	*2.8*	-	*3.4*
Emerging learners				
107	3	33	68	9
109	0	2	2	1
110	0	1	3	6
112	0	2	9	5
114	1	3	21	2
115	0	8	20	9
116	1	3	8	7
118	3	15	-	10
Group M	1.0	8.4	18.7	6.1
Group SD	*1.3*	*11.0*	*23.0*	*3.3*
Proficient learners				
101	0	5	4	14
102	1	14	18	13
103	4	6	10	48
111	3	12	18	27
124	0	4	4	10
126	9	10	14	55
Group M	2.8	8.5	11.3	27.8
Group SD	*3.4*	*4.1*	*6.4*	*19.4*

Note: Scores ranged from 0 to 100 for each assessment
Note: Dashes indicate that participant did not reach that level of proficiency

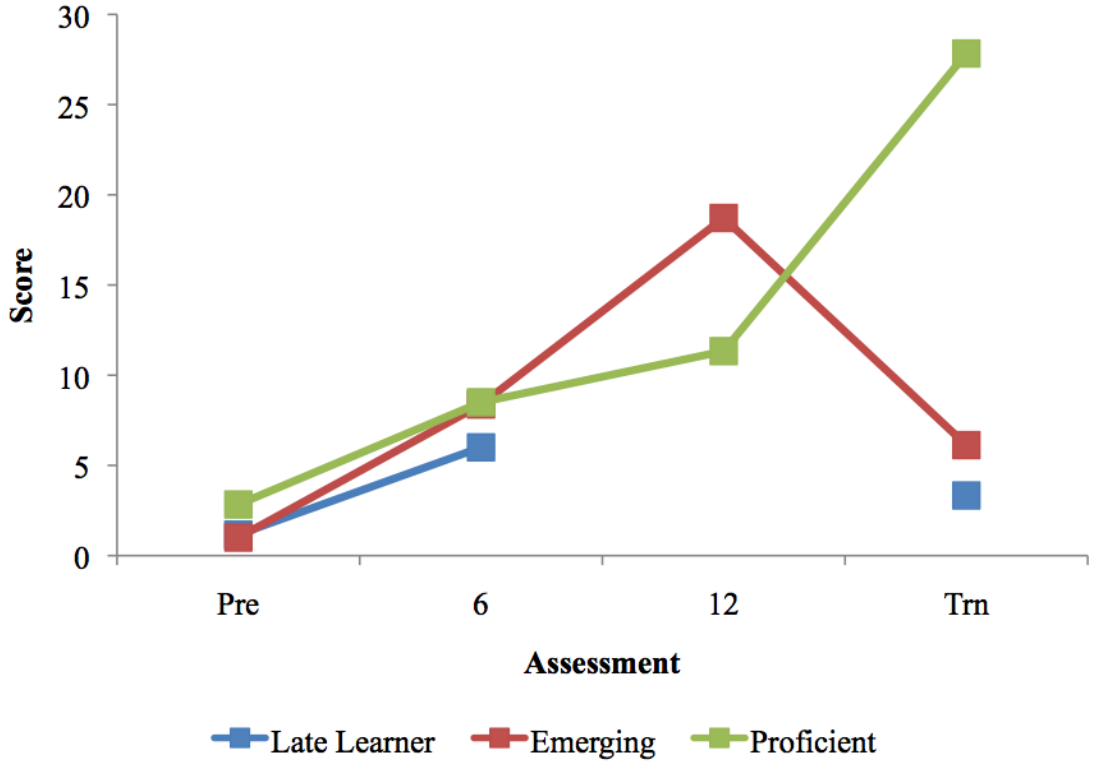

Figure 6. Mean self-efficacy scores for Late, Emerging, and Proficient Learners at pre-acquisition, six catches, 12 catches, and pre-transfer

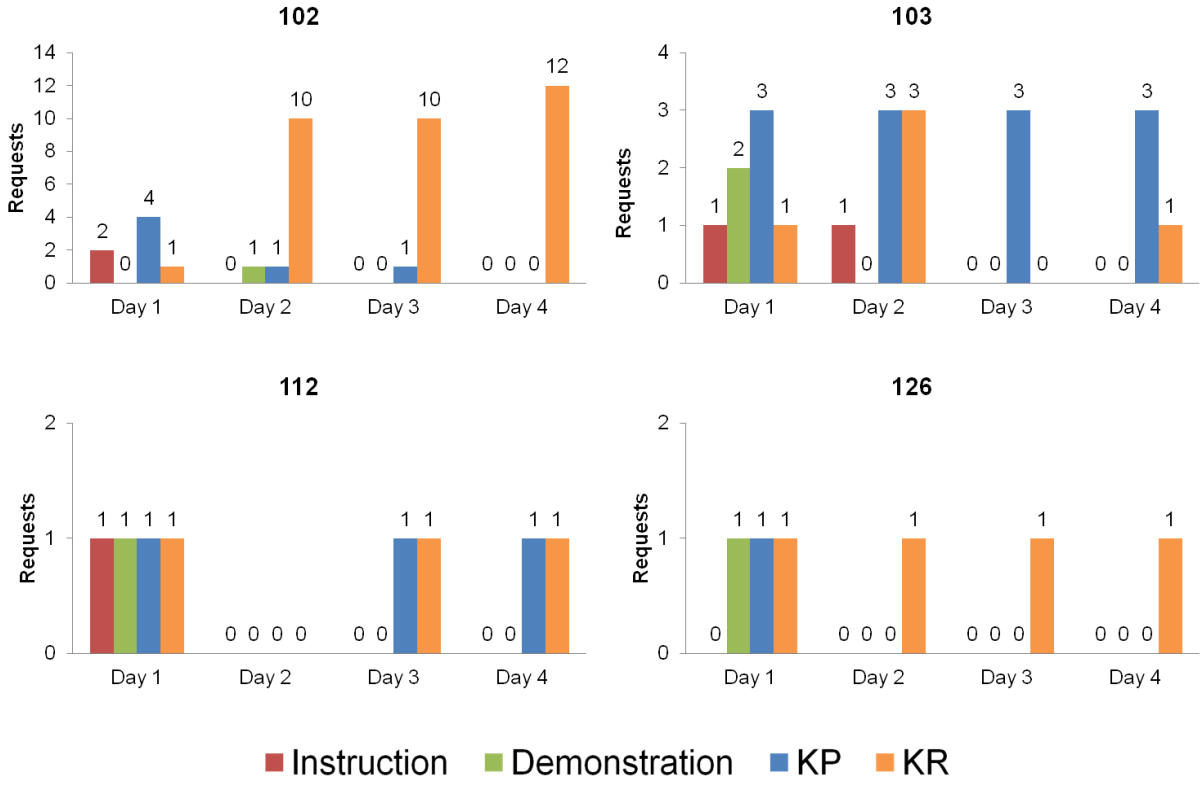

Figure 7. Number of requests for each type of IA during the four days of acquisition for participants 102, 103, 112, and 126

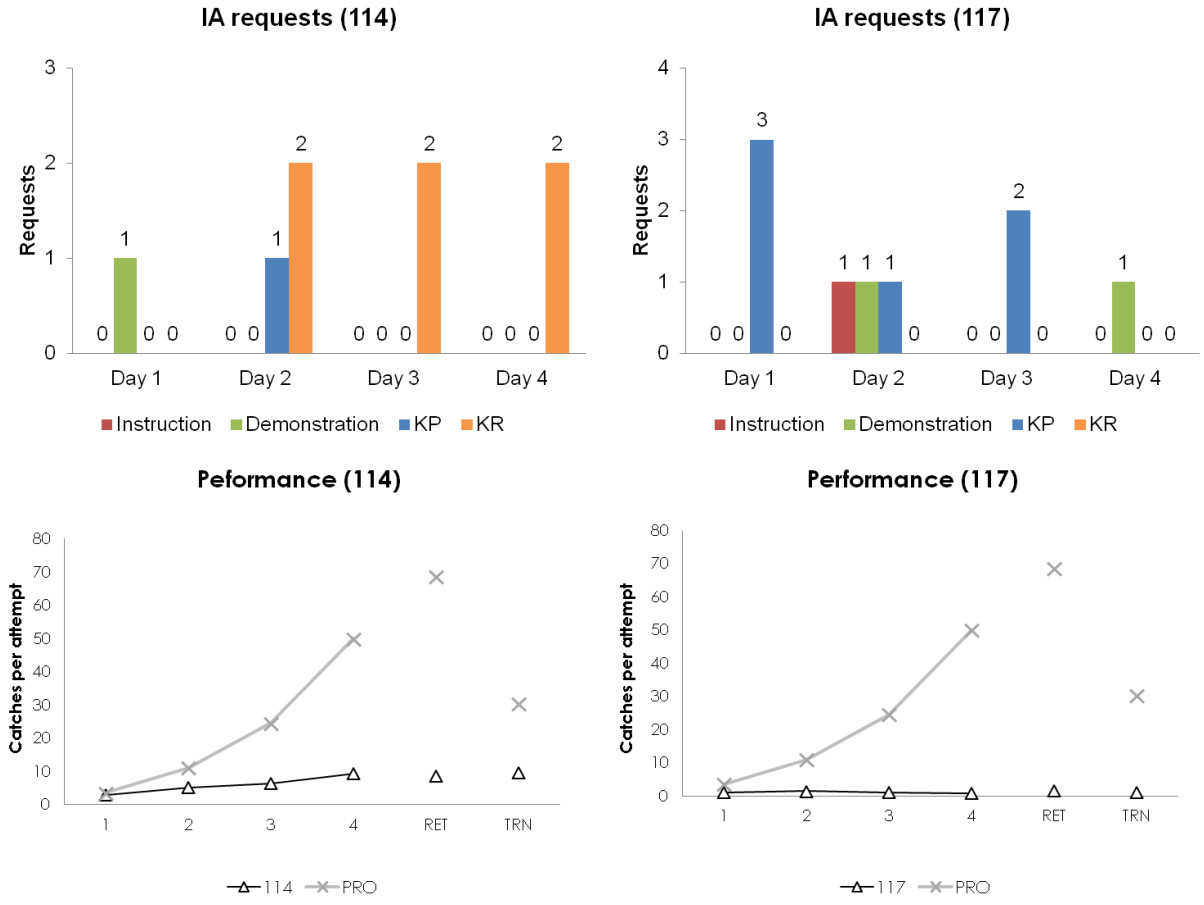

Figure 8. Requests for IA and performance during acquisition, retention, and transfer for participants 114 and 117

Table 13. Strategy use for participants in Late, Emerging, and Proficient groups

Group	Participant	Strategy
Late Learners	113	EMULATION – Matching instructions / demonstration
		PRACTICE STRUCTURE – Repetition
	117	NONE
	120	PRACTICE STRUCTURE – Segmentation
	121	PRACTICE STRUCTURE – Segmentation
	122	NONE
	123	ATTENTIONAL FOCUS – Directing / controlling movement
Emerging Learners	107	EMULATION – Using tips to diagnose / correct
	109	PRACTICE STRUCTURE – Repetition
	110	ATTENTIONAL FOCUS – Directing / controlling movement
	112	ATTENTIONAL FOCUS – Directing / controlling movement
		PRACTICE STRUCTURE – Repetition
	114	ATTENTIONAL FOCUS – Finding the feel
	115	NONE
	116	EMULATION – Using tips to diagnose / correct
	118	NONE
Proficient Learners	101	EMULATION – Using tips to diagnose / correct
	102	ATTENTIONAL FOCUS – Counting tosses
	103	EMULATION – Matching instructions / demonstration
	111	ATTENTIONAL FOCUS – Tracking colors / finding rhythm / counting tosses
		EMULATION – Matching instructions / demonstration
	124	ATTENTIONAL FOCUS – Tracking colors / counting tosses
	126	ATTENTIONAL FOCUS – Counting tosses

Vita

David Laughlin was born on March 16, 1980 in St. Louis, MO. Prior to attending the University of Tennessee, he completed a Bachelor of Arts degree in Communication at William Jewell College (Liberty, MO) and a Master of Science degree in Exercise and Sport Sciences at Ithaca College (Ithaca, NY). In May 2012, he received his Doctor of Philosophy degree in Kinesiology and Sport Studies with a specialization in Sport Psychology and Motor Behavior.